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A Study of the Effects of Thinking Maps on the Achievement of Students in Middle Grades Science

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by

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DEDICATION

As with most dissertations, a lot of time and many people figured into the equation before it was completed. Mine was no different. That said, this work is dedicated to several people who have been down the road with me and kept me on the straight path. To my parents, Stuart and Ann Hughes, who always encouraged me to excel at whatever I endeavored to do and be whoever I aspired to be. To my children, Ashley and Cole, I pray one day you will understand what I did and why I did it. To my best friend, Raye Aragon, who lifted my spirits and kept me going when I did not think I could continue. And most importantly, to my loving and patient husband, James Patrick Akin, for being my biggest cheerleader, for being my rock and firm foundation, for saying I could do it when I did not think I could, for holding me when I cried at setbacks, and for celebrating even the smallest successes with me. I could not have done it without you! I love you big much! Philippians 4:13 – I can do all things through Christ who strengthens me.

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ABSTRACT

The purpose of this study was to determine if the usage of Thinking Maps® influenced the achievement scores of middle grades students in science on the Georgia Criterion-Referenced Competency Tests (CRCT) over a period of two years. Science test scores for the 2012-2013 and 2013-2014 school years were analyzed by grade level and usage in SPSS and SAS, and after transformations were completed, non-parametric ANOVAs were conducted based on non-normal distributions. Science teachers were surveyed regarding their perceptions and usage of Thinking Maps®. The scores and surveys were then analyzed for simultaneous effects.

The results of the study for the 2012-2013 data indicated grade level was significant and did influence a variation in scores, with seventh grade having a greater frequency of scores above 850. Usage of Thinking Maps® was not significant and did not influence a variation in scores. Friedman's non-parametric ANOVA showed 9.11% of the variance in scores was influenced by grade level and usage. The 2013-2014 data indicated grade level was significant and did influence a variation in scores, with seventh grade having a greater frequency of scores above 825. Usage of Thinking Maps® was significant and did influence a variation in scores. Friedman's non-parametric ANOVA revealed 23.2% of the variance in scores was influenced by grade level and usage. An interaction effect for either year could not be determined because of non-normal distributions and sample origination differences. Therefore, a comparison of means for grade level and usage was conducted. Teachers who used Thinking Maps® had higher mean scores than those who did not. Based on the findings, it may be concluded there appears to be a relationship between the perceptions of teachers and consistent usage of Thinking Maps® in middle grades science and the increase in achievement score means of the students who used them regularly and with fidelity.

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CHAPTER ONE

INTRODUCTION

Middle school students are a distinct group of students with their own characteristics. Teaching them can be a challenging and daunting prospect. It often requires multiple ways of manipulating information in order for students to form connections to what they are learning. One strategy is to use graphic organizers. While utilizing graphic organizers is not a new concept, there are always new developments. One of those is Thinking Maps®.

Purpose of the Study

The purpose of this study is to identify teacher perceptions concerning the use of Thinking Maps® and to examine the effect of implementing Thinking Maps® on middle school students' academic achievement in science.

Conceptual Framework

The beliefs that guide the study are generated in part from David P. Ausubel's work with advanced organizers (1960). Ausubel was a psychologist whose Subsumption Theory of Meaningful Verbal Learning stated that a very large amount of what enters a student's brain is visual, and students take existing knowledge and enmesh it with new knowledge they receive in school (1960, 1963, 1978b). His work with advance organizers, conceptual representations used to organize information, literally redefined education, but was not widely known or accepted by the critics (1978a). The large body of graphic organizers available today, including Thinking Maps®, stem from much of Ausubel's work.

Middle school students are a diverse group due to physical, mental, intellectual, and emotional growth differences. In one class, a teacher might have students who cannot think past the concrete level, students who can think abstractly, and everything in between. This can make it incredibly hard for teachers of middle school students to pinpoint techniques and strategies to use in the classroom for high percentages of mastery. According to Jean Piaget's theory of cognitive development, middle grades students fall either into the concrete operational stage (7-11), characterized by students who are beginning to think abstractly but still may depend on the manipulation of concrete objects to help them learn, and the formal operational state (11-15), characterized by students moving from concrete-based thinking to greater abstract and logical thought, who may not necessarily depend on the use of concrete objects to aid them in learning (American Academy of Child and Adolescent Psychiatry, 2012; California Department of Education, 1989; Caskey & Anfara, 2014; Edwards, Hopgood, Rosenberg, & Rush, 2000; McLeod, 2010). Because of the uncertainty that exists with a student still being in the concrete operational stage or in the formal operations stage, teachers require tools and resources that allow students in both stages to adequately showcase their work without pointing out the difference in the students' cognitive developmental levels.

Background

This study was chosen as a result of the school system in which the researcher is employed adopting the Thinking Maps® program at the onset of the 2011-2012 school year. A four-person team from each school in the system of eighteen schools was chosen to be on the school's redelivery team. A four-day Training of Trainers event was delivered during the third week of June of the summer of 2011, with the intent that each team would redeliver the training

to each school's faculty during the pre-planning period prior to the opening of school. Once the initial training was completed by the redelivery teams, each teacher was expected to provide samples of students' work to their principals over the course of the first four months after introducing a few of the eight Thinking Maps® at a time. The principals would in turn share them at their administrative meetings with the superintendent, the deputy superintendent for instruction, and the curriculum directors for the elementary, middle, and secondary levels to show the depth at which the program was being utilized.

Since the researcher was on a redelivery team, she developed an interest in seeing evidence of the research that had been presented during the training. Her area of interest was middle school curriculum, so her search centered on middle school uses of Thinking Maps® in the content area subjects.

Extensive searches conducted revealed eight quantitative or qualitative studies and many scholarly articles in the literature on the effective uses of Thinking Maps® centered on elementary schools and their application of the maps in Reading, Writing, Language Arts, and Mathematics. Three other studies were completed on secondary and post-secondary education. Unfortunately, there was only one study conducted at the middle school level, at Tuttle Middle School in Catawba County, North Carolina. The administration reported that from 1994-1996, the scores on the North Carolina End-Of-Year Test for writing increased from 43% to 73% for the eighth grade (Hyerle, 2000). Hester, Owen, Piekarski, and Hildebran (1995) reported the same findings at the same school as an increase in writing, reading, and other achievement test scores, but did not include the data from the original report.

Significance of the Study

Even though the effects of using Thinking Maps® on student learning outcomes has been studied at the high school and elementary levels to a greater extent, there are only a few studies focusing on middle level students. This study investigates the extent to which Thinking Maps® affect academic achievement in middle grades science. In addition, teachers' perceptions on the use of Thinking Maps® in learning were investigated through surveys. Because of the paucity of research at the middle school level, it is important that there is an addition to the literature for this developmentally diverse age group, to see if the Thinking Maps® program works and improves learning.

Definition of Critical Terms

For purposes of this study, the following definitions will apply:

Academic Achievement is achievement as measured formally by the Georgia administration of the Criterion-Referenced Competency Tests (CRCT) and the Georgia Milestones Assessments (GMAS).

Common Core Georgia Performance Standards (CCGPS) are standards adopted for use across 47 states, adapted for Georgia, that provide consistency in learning for college, career, and workforce development.

Criterion-Referenced Competency Test (CRCT) is a non-standardized test developed and administered in the state of Georgia to measure state standards instruction in grades 2-8.

Georgia Milestones Assessment System (GMAS) is the standardized test developed and administered in the state of Georgia to measure state standards instruction in grades 3-12.

Georgia Performance Standards (GPS) are instructional and curriculum standards developed by the Georgia Department of Education with specific standards at each grade level, tested by the Georgia CRCT.

Graphic organizer is a tool that organizes information visually.

Middle school is a school incorporating grades 6 through 8.

Thinking Maps® is a set of eight visual-verbal organizers developed by David N. Hyerle (1993) that uses specific thinking processes in which to organize data, ideas, or information:

Brace Map is one of eight Thinking Maps® that identifies whole-to-part relationships.

Bridge Map is one of eight Thinking Maps® that shows relationships in analogies.

Bubble Map is one of eight Thinking Maps® that describes a topic.

Circle Map is one of eight Thinking Maps® that defines a topic in context.

Double Bubble Map is one of eight Thinking Maps® that compares and contrasts two topics.

Flow Map is one of eight Thinking Maps® that sequences an event or gives directions or instructions.

Multi-Flow Map is one of eight Thinking Maps® that shows cause-and-effect relationships.

Tree Map is one of eight Thinking Maps® that categorizes, classifies, or organizes information.

Assumptions of the Study

The assumptions within this study are:

1. Teachers use Thinking Maps® as a result of a system-wide instructional initiative.
2. Students use Thinking Maps® in all content-area and connections classes.

In addition, all students take the Georgia Criterion-Referenced Competency Test in April, which includes grades 6-8 at the middle school level. During the 2014-2015 academic year, middle schools will administer the Georgia Milestones Assessments (GMAS) in place of the Georgia CRCT and Georgia EOCT. Results of this study are applicable only to the Georgia school system in which it takes place.

Limitations of the Study

The limitations of the study include:

1. Individual differences in teachers.
2. Teachers have varying levels of teaching effectiveness due to different levels of expertise and professional training.
3. Students in each grade level's content-area classes may not receive the same instruction using Thinking Maps®.
4. Teachers new to the school system may not have the same experience or staff development in the implementation of Thinking Maps® as those teachers who received instruction in the use of Thinking Maps® during the initial and subsequent training.
5. Students may have different learning styles or preferences, and academic achievement levels.

Delimitations

1. The population of this study is delimited to middle grades students in grades 6-8.
2. This study is delimited to science classes.
3. The population of this study is delimited to students in a mid-sized school system in west central Georgia.

Biases of the Study

A bias applicable to this study could be that if a teacher was a member of the redelivery team, then he/she may have a greater buy-in or vested interest in the usage of Thinking Maps® in his/her classroom. Additionally, the teacher might have a deeper knowledge of the inner workings of Thinking Maps® and its use. Conversely, a teacher who was not a member of the school's redelivery team may refrain from proper utilization of Thinking Maps® within the middle school curriculum or not use them at all.

Personal Statement

The researcher was chosen to be on the Thinking Maps® training of trainers team from in 2011. The team included a teacher from each content area: English/language arts, math, science, and social studies. The assistant superintendent for instruction had seen a presentation on Thinking Maps® and selected it as the newest school improvement initiative, so the objective was to learn about and redeliver the training to colleagues.

As an educator, the researcher was initially intrigued in the Thinking Maps® program because of the potential use in the classroom as a way for students to organize and manipulate information. She had also been on the training team for Max Thompson's *Learning-Focused*

Schools initiative, which included many graphic organizers whose functions were the same as some of the Thinking Maps®. Because she believed students must have multiple encounters with information to make permanent connections to learn content, she valued the use of graphic organizers, which included some Thinking Maps®. However, there were also other ways in which students evaluated and used data or information that may supersede Thinking Maps® (e.g., Venn diagrams, T-charts, outlines). Due to the diverse training the researcher had involving the use of graphic organizers, she believed she could draw objective conclusions regarding the use of graphic organizers and Thinking Maps®, and personal bias will be reduced more as a result than if she had only training in Thinking Maps® and no other formal training in graphic organizers to which she could make a comparison.

Statement of the Problem

Educators constantly seek new instructional tools or innovative programs when student learning outcomes are not at the desired level. When so much emphasis is on standardized testing, there is concern that students will have limited opportunities to engage in critical thinking and higher-order skills such as developing analogies and identifying cause-and-effect relationships. The challenge, then, is maintaining high standards while teachers teach every child and leaving no one behind.

To meet this demand, it is crucial to provide teachers with quality tools and resources to help students succeed in the classroom. Teaching middle grades students can be particularly challenging, as current brain research indicates that the brain is not ready for true abstract thinking until the early to mid-twenties. Giving students the tools with which to organize information is one strategy educators can utilize to develop abstract and critical thinking skills,

aid in concept acquisition and retention, and make connections in the content areas. One possible means to give students the tools to organize information is to use the Thinking Maps® program to connect new knowledge and think critically. Thinking Maps® are a series of eight visual information organizers developed for eight basic cognitive processes: defining, describing, comparing and contrasting, classifying, sequencing, causes and effects, whole-to-part relationships, and analogies. But, do Thinking Maps® help students with content attainment? This study is concerned with the educational progress of middle grades students using Thinking Maps®, and therefore, it is important to study Thinking Maps® as a viable resource to help students learn science in the middle school.

The brace map Thinking Map® was designed to break information, such as the systems of the body, the parts that make up the electromagnetic spectrum, or the types of rocks into the principal parts in the whole-to-part relationship. Doing so allows students to see visually how objects or ideas can be broken down into smaller parts. In this way, students can better see how the smaller parts may work together to make up the whole, building a spatial relationship as well as an organizational chart.

The bridge map Thinking Map® was designed to help students create analogies. Creating analogies can help students think more deeply, increasing their critical thinking and reasoning abilities and helping them to build their ability to think abstractly. By increasing the ability to reason and think critically students' ability to solve problems and reason better as to why something occurs. For example, to introduce students to the types of chemical reactions, the analogy of couples at a middle school dance and the different combinations of partners that are created helps students to understand better what happens. With a synthesis reaction, where carbon and oxygen react to generate carbon monoxide, an analogy might be to have a boy plus a

girl equal a couple on the dance floor. In a double-replacement reaction, if hydrochloric acid (HCl) and sodium hydroxide (NaOH) are combined, the two dancing “couples” break apart and change “partners,” generating sodium chloride (NaCl) and water (H_2O). Thus, the students are able to visualize the changes during each reaction type by visualizing the different partner combinations, leading to a better understanding of chemical reactions.

The bubble map Thinking Map® was designed to describe characteristics, properties, or qualities of the attributes of something. In science, the bubble map could be used to describe the characteristics of a specific layer of the atmosphere or the ocean, the properties of solids, liquids, gases or plasmas, or describe the characteristics of a particular biome, such as the taiga or maritime forest. Being able to describe characteristics of a specific scientific concept leads to a better understanding of how that concept contributes to the content being taught. For example, if students know the properties of the four main states of matter, they are better able to understand the molecular motion of each state and how the four states function in the natural world.

The circle map Thinking Map® was designed for students to generate lists of what they know about a topic, brainstorm, or relate information associated with the prior knowledge they might have of an impending topic. In the science classroom, this might be helpful used as a KWL or pre-assessment to gauge the prior knowledge students have about content. Additionally, it could be used to brainstorm on a topic. This could including anything from what students know about the clastic sedimentary rock group, animals existing in the maritime rain forest, to information about the Periodic Table of the Elements.

The double bubble map Thinking Map® was developed as being similar to the Venn diagram, where two things are compared and contrasted. This map is pertinent to the science classroom in that many comparisons are made within a topic being taught. For example,

students might compare and contrast shield and cinder cone volcanoes, animal and plant cells, or homogeneous and heterogeneous mixtures. Students using comparative thinking improve their critical thinking, which increases their comprehension and leads to better learning of the concept. Students comparing shield and cinder cone volcanoes would have to remember that the lava emitted from a shield volcano flows faster and over a larger area than that of a cinder cone, which would help the student to realize that because of this, the lava from the shield volcano has a lower viscosity.

The flow map Thinking Map® started as a response to flow charts, showing the sequences of events, timelines, directions, procedures, steps, or the order in which things occur. All of these are especially relative to the science classroom. Students are able to make greater connections to the content they are learning if they know processes in their correct order. For example, students tracking the progression of the history of atomic theory trace how the model of the atom developed over time and can better see the advances made in atomic theory as a result. Another example is recounting or retelling the steps of how to complete the procedures of a lab activity, which spans all grade levels. Being able to recall the steps leads to better understanding of the process of the activity, whatever it happens to be. Greater comprehension occurs as a result, just as it does when having a student retell a story she read.

The multi-flow Thinking Map® was designed to show cause-and-effect relationships, or to show the consequences of an event. In the science classroom, it gives students the opportunity to predict what they think will happen during an investigation and show the results. For example, students investigating acids and bases predict the identity of common substances and proceed to test the substances using an acid-base indicator. The color the indicator turns the substance being tested shows the presence of an acid or a base, and the student can then record

the effect or the result. Students can take the information gleaned from the investigation and produce an argument based on their results. Being able to argue a position effectively leads to increased abilities in critical thinking and reasoning, as well as in scientific communication.

The tree map Thinking Map® was designed for students to classify, sort, group, categorize, and organize information, which is invaluable in the science classroom. Students can use the tree map to organize information, which then is used as an aid to study. For example, students can generate a tree map on ocean zones and show pertinent facts and information they research or write down as they learn about them. Another example is generating a tree map for conduction, radiation, and convection during the study of thermal energy. The students can then add examples, illustrations, or diagrams to help them commit the information to short- and long-term memory.

Using a program such as Thinking Maps® may help students process and retain information in their science classroom. The maps provide visual-spatial aids on which students can record information they learned or discovered. With so many different types of graphic organizers and visual-spatial resources available in education today, the Thinking Maps® program may narrow the field for middle school students and aid them in learning science content and concepts much easier than deciding ways to record what they need to know.

Research Questions

The following research question will guide this study:

1. To what extent do Thinking Maps® affect middle grades students' academic achievement in science?

2. What are teachers' perceptions about the use of Thinking Maps® with middle grades students?
3. What, if any, is the relationship between the use of Thinking Maps® and teachers' perception and implementation in middle grades?

Summary

Educators are always looking for strategies, resources, and programs to help their students learn. One program being used is Thinking Maps®, which was developed by David Hyerle to take the place of the vast number of graphic organizers available and use eight basic brain processes he identified to organize and interact with information so that students can think critically and learn the concepts being taught. This study examines the use of Thinking Maps® in content-area learning to see if higher usage yields better results in content acquisition. Teachers will be surveyed for their thoughts and perceptions of the program and if they believe it does what it was intended to do: help students learn science content. This study is significant in that if the program does not contribute to learning, another avenue for students to use to learn science content should be investigated.

CHAPTER TWO

REVIEW OF LITERATURE

With closer scrutiny and ever-increasing demands on education from the U.S. government for many years in the guise of the *Elementary and Secondary Education Act* and the *No Child Left Behind Act of 2001*, and more recently *A Blueprint for Reform: The Reauthorization of the Elementary and Secondary Education Act* (2015), along with other mandates, states and local school systems have struggled to increase student successes. Educators are looking closer at research-based instructional strategies and educational practices to get the most out of their carefully measured budget, with their students' academic achievement centrally in focus. Additionally, new theories about how the teen brain learns have been recently hypothesized giving credence to some of the theories, strategies and practices used by the nation's educators, including brain-based learning, metacognition, graphic organizers, and another incarnation of visual organizers, the Thinking Maps® program. This study will focus on the use of Thinking Maps® in middle grades science to determine if there is a statistically significant effect on student achievement. Teachers' perceptions of the use of Thinking Maps® will also be examined to determine if they believe there is a positive impact on student learning and to investigate the relationship between these perceptions and student achievement.

Brain-Based Learning

Eric Jensen (2008, p.4) defined brain-based learning in *A Fresh Look at Brain-Based Education* as the "engagement of strategies based on principles derived from an understanding of the brain," and McCall (2012, p. 42) defined brain-based learning as "an approach that reflects the interrelatedness of the mind, brain, and body." While there should be no doubt that all learning has something to do with the brain, the issue at hand right now is what strategies educators should utilize to maximize their students' learning. Our current limited knowledge of exactly how the brain works is keeping this issue in the forefront of educational debate. What we currently know about how the brain learns, that is, the science of the brain, and the educational practices used by educators need to be cohesive, meaning educators need the tools and resources that best help the student learn according to what we know about the brain. Educational practices should not include the fad strategy of the moment, even though meta-analyses indicate brain-based learning "leads to greater academic achievement than traditional teaching methods" (Edelenbosch, Kupper, Krabbendam & Broerse, 2015; Gözüyeşil & Dikici, 2014, p.646). Because we do not know all there is to know about how learning occurs, we should be very careful when using any teaching strategies that might have been developed from the results of neuroimaging studies (Willis, 2007). A study by Pashler, McDaniel, Rohrer, and Bjork (2008) concluded the widespread use of learning-styles measures in educational settings is unwise and a wasteful use of limited resources. An example of this would be teaching students based on what has been identified as "visual learning style."

Jensen (1996 & 2005) stated that visual images make up 90% of the information that enters the brain, and the eyes register 36,000 visual images in an hour. The brain devotes the greatest part of its information processing to these visual images as compared to non-visual, abstract information (Plotnik & Kouyoumdjian, 2014). Even with that, the brain does receive

information from all five senses, leading researchers to believe there are really no specific learning styles, but what matters the most is being exposed to content in multiple ways (Pashler, et al., 2008). Other researchers have shown that emotion and personal connectivity contribute to a person's ability to pay attention in order to learn information necessary to the topic (Yeager, 2004). In the PBS series *The Secret Life of the Brain*, the statement "the brain is not a thinking machine, but a feeling machine that thinks" (Grubin, 2001) shows what the ancient Egyptians knew to be partially true: emotion, even if it doesn't come directly from the heart, is important to learning. The brain takes the influx of information coming into it from different sources, discards what it determines to be irrelevant, then makes connections within the neural network, and places the necessary information into long-term memory for later use and retrieval (Smith & Kosslyn, 2013). Making visual patterns, such as flow charts, analogies, or taxonomic charts to make sense of the huge amounts of information coming in is a task in which the brain excels. Yeager (2004) said that when students can link abstract ideas to a visual image, the patterns can independently alert the brain to search out a recognizable organization in which to store the new information. When the students become familiar with these organizational patterns, they develop the ability to think and learn at higher levels, which in turn increases the amount of activity in the brain and can lead to an increase in deeper thinking and retention. Some of the newest studies have identified three brain systems that may process visual images, one each for shape, color, and motion or perspective (Society for Neuroscience, 2012). Ultimately, areas of brain activation are able to use the graphic representations of these basic brain functions and patterns for increased ability to think in the upper levels of Bloom's Taxonomy (Brown, 2003).

In any event, there is a consensus among those in neuroscience and education that caution must be observed when taking information from brain-based studies and applying it to education

(Willis, 2007). It is accepted that for students to learn, new content must be meaningful to the learner's experience or it will be disregarded by the brain as unnecessary (Bellah, Robinson, Kaufman, Akers, Haase-Wittler, & Martindale, 2008). However, until a clear definition of how students' brains place importance (metacognition) on the knowledge, organize it, and store it has been determined, the changes to the foundations of education will not occur (Gözüyeşil & Dikici, 2014). Willis (2007) may have said it the most succinctly:

> For now, a combination of the art of teaching and the science of how the brain responds metabolically to stimuli will be the best guide for educators in their efforts to find the best *neuro*-logical ways to present information in ways that potentiate learning. (p. 699)

Metacognition

Metacognition has been defined in education as how people think about thinking, or their awareness of what they know or do not know (Flavell, 1976). It can also mean those abilities we have and use to get meaning from something we have read or the steps we take to solve some kind of problem (Flavell, 1976). While knowledge of the process of thinking about how one thinks has been around for many years, it is most commonly associated with developmental psychologist John H. Flavell, a professor at Stanford University, who first used the term "metacognition" in 1976. According to Flavell, there are two distinctive divisions of metacognition: metacognitive knowledge and metacognitive regulation (1976, 1979).

Metacognitive knowledge focuses on what one knows about the cognitive processes and how to control or accommodate for them. Metacognitive knowledge can be subdivided into three categories: person variables, task variables, and strategy variables (Teaching Excellence in Adult Literacy (TEAL) Center, 2012). Person variables refer to being aware of one's own

strengths and weaknesses in being able to learn new information or a new skill, task variables involve being able to decide what is known about a task, purpose, or what is needed to complete a task, and strategy variables are those used to activate the prior knowledge about a task so that a plan of attack to accomplish the task can be formulated (TEAL, 2012). A singular example given by Livingston (1997) streamlines Flavell's idea, "I know that I (*person variable*) have difficulty with word problems (*task variable*), so I will answer the computational problems first and save the word problems for last (*strategy variable*) (Section 4, paragraph 5)." This ability to look at a problem or task, surmise the deficiencies in knowledge of the topic, and generate a plan to increase the knowledge and develop a plan to execute the task affords students greater problem-solving and critical thinking skills to be successful at all levels (Joseph, 2010).

Metacognitive regulation refers to how a person regulates or controls his own learning by using three critical skills: planning, monitoring, and evaluating (Efklides, 2014; Livingston, 1997). The planning phase requires thinking about what is known about a task topic, choosing an appropriate plan of attack and acquiring the appropriate information needed to carry out the task (Livingston, 1997). This planning phase might include selecting an organizer to use to organize information in order to manipulate it or use it to solve the task or problem. When monitoring progress, performance must be taken into account to determine if the goal is being met. Evaluating the completed task entails the appraisal of the steps taken to complete the task as well as the quality of the finished product. Examples of this could be the planning and execution of a paper on the similarities between Gandalf in *The Lord of the Rings* and Jesus Christ, or designing and building a Rube Goldberg machine to drop pet food into a bowl under certain conditions. The success or failure of the product is not only due to the finished product,

but the steps the student had to take, sometimes implicitly, in order to complete the task to show what he learned.

It may be that students do not have the innate metacognitive ability to realize what they know or don't know, or plan, monitor, and evaluate their products, but these skills developed (Joseph, 2010; TEAL, 2012; Turner, 2011). Some strategies for developing metacognition include modeling the thinking-aloud process, activating prior knowledge, outlining or other forms of note-taking, pre-writing strategies, using graphic organizers such as anticipation/ reaction guides or concept maps, generating mnemonics, breaking down words into roots, prefixes, and suffixes, using checklists, and utilizing problem-solving strategies, such as deconstructing questions or problems, to name a few (Efklides, 2014; Joseph, 2010; Livingston, 1997; Pacheco & Goodwin, 2013; Ritchhart, Turner, & Hadar, 2014; TEAL, 2012). Since Thinking Maps® allow students to organize and represent information in different ways, it can be hypothesized that they support students' metacognitive thinking based on how literature identifies metacognitive thinking strategies as described above.

Adolescent Learners

Middle school students are a diverse group given their developmental and cognitive differences. In one class, a teacher might have students who cannot think past the concrete level, students who can think abstractly, and everything in between. This can make it incredibly hard for teachers of middle school students to pinpoint techniques and strategies to use in the classroom for high percentages of mastery.

Granville Stanley Hall, the first president of the American Psychological Association, was one of the first psychologists to identify adolescents as a disparate group in his book, *Adolescence: Its Psychology and Its Relations to Physiology, Anthropology, Sociology, Sex,*

Crime and Religion, in 1904 (Caskey & Anfara, 2014). Later, Jean Piaget's work in the stages of cognitive development set the groundwork for change in education. He determined that students around the ages 7-11 were in the concrete operational stage. The concrete operational stage is characterized by students who are beginning to think abstractly but may still depend on the manipulation of concrete objects within the learning process (Piaget, 1969). In the earlier end of this age range, students may evaluate logical thinking with only concrete evidence (Edwards, et al., 2000). Their thinking changes over time with the significant changes in the brain's prefrontal cortex, leading to increased ability to conserve, plan, classify, make decisions based on reasoning, and determine possible consequences, with an increased attention span (Caskey & Anfara, 2014). Subsequently, learners at this level need more structured learning experiences and activities (Caskey & Anfara, 2014). The structured learning experiences help students bridge the gap between concrete and abstract.

Following concrete operations, the next stage of Piaget's theory of cognitive development is the formal operational stage, which encompasses the 11-15 year age range (Piaget, 1969). It is characterized by students moving from concrete-based thinking to greater abstract, logical thought that does not necessarily depend on the use of concrete objects in the learning process (American Academy of Child and Adolescent Psychiatry, 2012; California Department of Education, 1989; Caskey & Anfara, 2014; Edwards, et al., 2000; McLeod, 2010). The two main characteristics of learners at this level include the ability to deductively reason hypotheses and possible solutions to solve a problem, and a propositional focus in which they can logically evaluate the validity of assertions without referencing real-world situations (Edwards, et al., 2000). Further, students at this stage develop greater ability for independent thought and metacognition, that is, knowing and being aware of what they know and do not know (California

Department of Education, 1989; Caskey & Anfara, 2014). Abstract thinkers benefit from challenging, less structured learning experiences (Caskey & Anfara, 2014).

Given the developmental and cognitive challenges of middle grades students, it is necessary for teachers to be aware of practices and resources to help their students learn. Providing learning opportunities for students in both concrete operational and formal operational stages makes sure students can learn and grow into abstract thinkers.

Graphic Organizers

While the term "graphic organizers" did not appear until the last half of the 20th century, these visual tools have been used for hundreds of years to organize information for various purposes: church and religious services, merchandise inventories, will asset lists, timelines, comparisons between sets in mathematics, charts, matrices, and many others. David Ausubel's (1960) ground-breaking work evolved into the theory that students could learn information quicker and with better retention if they had a structured visual for organizing the information. This led to the development of many of the graphic organizers that we see today (Gibbs, 2009). In addition, the work of some of the best education minds of the day, such as Robert Marzano, Carol Ann Tomlinson, Jay McTighe, Howard Gardner, Thomas Armstrong, Grant Wiggins, and Dinah Zike, among many others, endorsed the use of graphic organizers in differing formats as a way for students to condense large amounts of information, organize it, and scaffold thinking around it (Gardner, 1983; Marzano, 2016; Tomlinson, 2010; Wiggins & McTighe, 2005; Armstrong, 1993). Furthermore, using these visual graphic representations for taking organizing concepts has been immensely helpful for students to take what they have read and make sense of it by constructing their own graphic representations in the Thinking Maps'® formats because

they can add their own creativity (Brown, 2003). Students are able to plan what they will do and follow through, making the information they find more easily understood (McKenzie, 1997). These graphic images give students something concrete that can aid them in making connections between what they have read and their own understanding of it (Coleman, 2003). Graphic organizers may also help students with disabilities make sense of the loads of information given to them (DiCecco & Gleason, 2002). DiCecco and Gleason (2002) conducted a study of middle school students with reading disabilities and found that students had significantly greater knowledge of the subject after using graphic organizers than those students who did not. Halvorson (2010), Dexter (2010), and Hernandez (2014) found that Title I students and students with disabilities did not like using graphic organizers but felt using them helped the students learn new content vocabulary with the addition of a visual aid markedly improving the learning of content-area curriculum, and increasing their attitudes toward reading and participating. In a study completed on students with disabilities in mathematics, Cully (2010) found they made better progress than their non-disabled peers when using graphic organizers. Manoli and Papadopoulou (2012) concluded that graphic organizers were "conducive on [sic] assisting students in activating prior knowledge, gaining insight into text structure, identifying as well as connecting the main ideas of a text resulting in better recall and retention of information" (p. 354). Cleveland (2014) found that while no clear answer could be made for or against the use of graphic organizers as an aid for organizing information or studying, the data indicated that when a student's cognitive load was very high, meaning the student is dealing with many concepts at once, "graphic organizers acted as a tool to facilitate learning" (p. 145). Chemistry students' attitudes for both chemistry and for the use of graphic organizers to help them learn key chemistry content grew more positive (Torres, España, & Orléans, 2014). McKinney (2007)

reported “the higher mean score on the chapter tests by the experimental groups in comparison to the control groups show promise in using graphic organizers in the [secondary] science classroom” (p. 77). When engaged in activities that required students to use critical thinking, graphic organizers were helpful (Torres, España, & Orléans, 2014). Unfortunately, there are so many available ways to organize data and information that it can seem daunting to the student who attempts it. Being able to pare down the sheer volume of graphic organizers available into a more manageable number for students to remember may help students make better use of these tools. This is where a program like Thinking Maps® could make a difference.

Thinking Maps®

During his doctoral research at the University of California at Berkeley in the early 1990’s, David Hyerle focused on graphic organizers and how they could help students. He put his efforts toward a system to “flexibly pattern information in order to construct understandings” (Hyerle, 2004, p. 12), which could lead to higher levels of thinking in the analysis, synthesis, and evaluation ends of Bloom’s Taxonomy (Gibbs, 2009). His research showed that “early mind-mapping techniques (in the 1970’s) facilitated open-minded thinking yet lacked the consistent structure and deeper levels of complexity required for today’s classrooms” (Hyerle, 2004, p. 7). Using the brain research of the time, Hyerle identified eight fundamental thinking processes that the brain uses to store and use information: defining, describing, comparing and contrasting, classifying, sequencing, cause and effect relationships, whole-to-part relationships, and analogous relationships (Hyerle, 1993). Using the cognitive processes and the graphic organizers that educators were utilizing at the time, Hyerle developed his own primitive graphic organizers, and by using the “maps” with the intent that students could relieve some of the load

on their short-term memory which would allow increased mental capacity to think at deeper levels with more understanding of the concepts they were learning, be more creative, and think more abstractly than was formerly possible (Brown, 2003). These graphic organizers evolved into what are now known as Thinking Maps®, eight specific maps to visually organize information. Because Hyerle developed each graphic representation to follow the pattern of the brain process for which he claims it stood, the natural tendencies of the brain could now be utilized to their fullest potential (Hyerle, 1993). For example, a student could use a tree map to organize facts about conduction and convection that could then be used in a double-bubble map to make comparisons. Hyerle (2004) stated,

> The combined practical, theoretical, and critical attributes of these different types of visual tools have informed the continuing evolution of Thinking Maps® into a 21st century language for learning, synthesizing many of the best qualities of these other types of visual tools: an evolution from the generative quality of brainstorming webs, the organizing structure of graphic organizers, and the deep cognitive processing found in concept maps (p. 7).

This flexibility enables students to take those basic visuals, which are systems of interconnected information, and organize their thinking by taking the content knowledge, transferring it to their visuals, and adapting it for themselves (Gibbs, 2009). Students can add illustrations or diagrams, color, symbols, mnemonics, and other embellishments to help them learn and remember content. This process ensures that the focus is on the affective domain, where students can develop metacognitive skills (Hubble, 2004).

The eight maps Hyerle developed are: the Circle Map, the Bubble Map, the Double Bubble Map, the Tree Map, the Flow Map, the Multi-Flow Map, the Brace Map, and the Bridge

Map. Collectively, they are called Thinking Maps®. According to Hyerle, each map corresponds to a fundamental cognitive process that allows people to compartmentalize information. For example, the double-bubble map is used for comparing and contrasting, which leads the student to find similarities and differences between the two items being compared. The tree map is used to organize facts under categories, and facts are chunked to be easily found or recognized. The flow map is used to show the progression of ideas or the procedures to accomplish a task, and the students must be able to distinguish the order in which an event occurs. The bridge map is used to build analogies, where students make comparisons between objects based on similarity or comparability with similes and metaphors. The brace map breaks something into its component parts, forcing students to think about the parts of a whole and how those parts fit together. The multi-flow map can show cause and effect relationships, making the student focus on the *why* and *how* something happens. The circle map is used to define a topic or to show the characteristics that make the topic what it is, such as the characteristics or properties of a liquid. Lastly, the bubble map can describe a topic, using adjectives to give a student the opportunity to use language to describe what he knows about a subject. When compared to the myriad of graphic organizers available, the Thinking Maps® are relatively static, which allows for use across many content areas, not only in education, but in business, medical professions, the military, and other applications as well. Hyerle (2004) believed there were five qualities to his Thinking Maps®: consistency, flexibility, developmental appropriateness, favoring integration, and reflection, and they could be utilized on a global level to distribute information. In addition, maps used for any class, be it math, English, foreign language, or wood shop use the same design, and the repetition and consistency in organizing information makes it helpful for students to organize information efficiently and use in across all content areas to enhance their

thinking (MacIntyre, 2004). These organizational patterns that can be utilized across disciplines included identifying similarities and differences, summarizing and note-taking, non-linguistic representations, and advance organizers (Dean, Stone, Hubbell, & Pitler, 2012; Marzano, Pickering, & Pollock, 2001). This universal use is important as Thinking Maps® collectively can be used as advance organizers and non-linguistic representations. Furthermore, similarities and differences can be represented in a Double-Bubble Map and a Tree Map can be utilized for summarizing and note-taking, for example, where students use the organizers to show what they know.

After twenty years of implementation, there is evidence for the usage of Thinking Maps®, most of which involved direct support and training from its creator. David Hyerle (2000) cites the results of several schools' implementation of Thinking Maps® in *A Field Guide to Using Visual Tools*. Margaret Fain Elementary School in Atlanta, Georgia, on the Georgia Test of Basic Skills, the forerunner of the Georgia Criterion Referenced Competency Test (CRCT), reading scores increased from 29% to 69%, and math scores rose from 32% to 63% in 1996. At Friendship Valley Elementary School in Carroll County, Maryland, on the Maryland School Performance Assessment Program (MSPAP), writing scores increased 27%, language scores rose 20%, and science scores rose 18.2% in 1996 after implementation. Additionally, Windemere Elementary School in West Orange County, Florida, on the Stanford 8 Achievement Test, reading scores increased from 68% to 80%, and math scores rose from 79% to 92% in 1997, and Waitz Elementary School, a 100% Title I school in Mission County, Texas, on the Texas Assessment of Academic Skills (TAAS), math scores increased from 41.2% to 76.5%, while reading increased from 62% to 88% in 1994 following initiation of the program. At Claremont Elementary School in Catawba County, North Carolina, scores on the fourth grade

North Carolina End-of-Year Test in writing showed an increase from 33% to 68% over the years 1993-1996, while at Chadbourne Elementary School in Columbus County, North Carolina, writing scores on the same test increased from 35% to 60% from 1993-1995, and at Morrisville Elementary School in Wake County, North Carolina, the writing scores increased from 32% to 76% from 1993-1996. Lastly, A. T. Allen Elementary School in Cabarrus County, North Carolina, on the North Carolina State End of Year Tests in 1998, math scores rose from 80% to 91%, reading scores increased from 77% to 89%, and writing scores rose from 29% to 77%. The one middle school mentioned by Hyerle was Tuttle Middle School in Catawba County, North Carolina, showed an increase in eighth grade writing scores on the North Carolina End-of-Year Tests from 43% to 73% from 1994-1996 (Hyerle, 2000). While these are impressive statistics, these were the reported significant gains; all scores were not mentioned and could tend to make the more positive scores suspect.

Most of the studies focused on elementary-age students. Gibbs (2009) tested to see if the reading achievement of third and fourth grade students would improve if they implemented the use of Thinking Maps®. Using the Tennessee Comprehensive Assessment Program (TCAP), the scores were analyzed in independent sample *t*-tests. Results indicated there was no evidence the length of implementation affected reading achievement, but there was a significant increase in student reading scores (Gibbs, 2009). Another study completed by Russell explored the impact of Thinking Maps® on reading comprehension achievement on fourth and fifth grade students using a repeated measures ANOVA and perception surveys. No significant difference in the reading achievement on the Texas Growth Index (TGI) for socio-economic status, ELP, gender, or ethnicity was noted, but there was a significant difference between the fourth and fifth grade scores (Russell, 2010). Sunseri studied the effects of using Thinking Maps® to generate

expository writing. She worked with fourth graders, ELL and non-ELL students, and found no significant difference between the treatment and control groups. However, there was a small difference in the ELL students' writings as compared to the non-ELL students' writings (Sunseri, 2011). Leary (1999) studied the effects of Thinking Maps® on the achievement scores of fourth graders in math, reading, and language arts. He used a 3-way ANOVA analysis of Stanford-9 test scores. Results indicated no significant difference between the treatment group and the control group on any of the variables, including race, gender, and previous achievement level (Leary, 1999). Also working with fourth grade students, Brown explored the students' use of Thinking Maps® to develop high-level reading comprehension tests. She found, using paired samples *t*-tests, that students showed significant improvement in both their ability to generate higher-order questions, and to answer questions generated by their peers (Brown, 2003). Hickie (2006) tested to see if an association existed between Thinking Maps® usage and student achievement in reading, English/language arts, and math. She studied fifth grade students and used paired sample t-tests and 3-factor repeated measures ANOVA to analyze the data. The results showed significant differences between the means for reading from 2003 and 2005, but no significant difference in the math means. There was also a significant difference between the English/ language arts mean scores for 2003 and 2005 (Hickie, 2006).

Robert Slavin and his colleagues (2009) at Johns Hopkins University conducted a meta-analysis of 79 upper elementary reading studies and their effect on reading achievement in 2009. They looked at two separate studies on Thinking Maps® in grades four and five by Leary (1999) and Hickie (2006), and noted the program has promise in helping students make gains in their reading achievement.

A study completed in 2013 on the effects of Thinking Maps® on the science achievement of 170 fifth graders in a northeast Georgia school system revealed the treatment group using the Thinking Maps® program underscored the non-treatment group by a mean of 23.8 points on the Georgia Criterion-Referenced Competency Test (Hudson, 2013).

According to Ball (1998), Thinking Maps® aided both traditional and nontraditional college students to increase their ability to retain what they read. In this study, the treatment group using Thinking Maps® outperformed the control group, in which the instruction was the same with no graphic organizers were endorsed, in 5 of 7 variables. The treatment group outperformed the control group in fast reading, comprehension, structure, vocabulary, and word parts. With each of these, $p < .01$. The other two variables were phonics and scanning. This could translate to middle school students by aiding them in content knowledge acquisition by acting as a study aid. Another study on college-age students was completed by Gallagher (2011). Students in the Advanced Nutrition and Metabolism classes at East Carolina University improved the organization and the clarity of their writing to evaluate dietary literature over four semesters. Students interviewed indicated they felt better about their ability to organize and write clearly and they were able to do it in a more concise manner.

Unfortunately, there is little data available for the middle grades regarding the use of Thinking Maps®. As reported by Hyerle (2000), Tuttle Middle School in Catawba County, North Carolina had an increase in scores on the North Carolina End-Of-Course Test in writing. From 1994 to 1996, students showed an increase at the eighth grade level from 43% to 73% (Hyerle, 2000). In a related study, DeCecco and Gleason (2002) examined if graphic organizers helped middle school students with learning disabilities. They showed that while the students

scored significantly higher on their post-tests, they also showed greater knowledge of the topics they studied than did the students who did not use graphic organizers.

Anecdotal records from over thirty North Carolina educators using Thinking Maps® indicate that many teachers are in favor of the usage of Thinking Maps®, some because Thinking Maps® help students navigate through information to which they are exposed, but because they help support thinking and help students explain and understand what they are learning (MacIntyre, 2004). Further, there is evidence that students who utilize information in different forms using Thinking Maps® in conjunction with other practices where students manipulate content-area knowledge in different ways, known as double-and triple-processing, gain a much deeper understanding of the content they are learning (Hubble, 2004). For example, during an initial lecture, a science teacher might have students outline the information presented on the history of atomic theory, which is known as structured note-taking (Thompson, 2003), then taking the information and developing a Tree Map to categorize specific information for each scientist involved, then developing a Flow Map showing the sequence of events in the development of atomic theory. Being immersed in the information and material in different formats enables students to better grasp what they need to know.

Summary

The review of the literature suggests the effectiveness of the use of graphic organizers and Thinking Maps® is somewhat mixed in its support of student learning in different content areas, namely reading, language arts, and mathematics at the elementary level. However, evidence has shown its use at the secondary and collegiate level has assisted students in their learning. Ball (1998) found Thinking Maps® helped both traditional and nontraditional college

students to increase their ability to remember and retain what they read. Additionally, Gallagher (2011) stated students in upper level undergraduate nutrition courses were better able to organize and coherently write article summaries using Thinking Maps®.

Students in the middle school range in age from 11-15. This developmentally diverse group has its own characteristics that can make it difficult for teachers to be specific about instructional strategies that allow students to learn to the mastery level. A class may have students in the concrete operational level of development and require more structured, manipulative, concrete instructional strategies through which they can learn. Other students in the class may be in the formal operational level, who are able to think abstractly and may not require as many hands-on, manipulative-based activities in order to learn some concepts. Because of the cognitive diversity in the classroom, middle grades teachers must be able to access a multitude of concrete and abstract activities, experiences, and instructional resources to cover the differences within this age range. Using tools such as graphic organizers, advance organizers, and other organizational strategies could serve as a unifying strategy for each of these developmental levels to manipulate, organize, and utilize pertinent information. Tools that could potentially help both concrete and abstract learners may be Thinking Maps®.

Concept Analysis Chart

TOPIC: Studies Related to Thinking Maps Usage

STUDY	PURPOSE	PARTICIPANTS	DESIGN/ ANALYSIS	OUTCOMES
Ausubel, D.P. (1960)	Test the hypothesis that learning can be facilitated by use of advance organizers	120 senior undergraduate students, 78 women & 32 men at Univ. of Illinois	Quantitative: one-tailed test	Assessment scores of students using advance organizers was higher than those not using
Ball, M.K. (1998)	Test to see if use of TM's helps improve reading scores	92 traditional & nontraditional Jr. college students in MS	Quantitative: 2-way MANCOVA; Qualitative: Questionnaire	Treatment group outperformed control group in 5 of 7 variables

Brown, C.A. (2003)	Test to see if elementary students could develop high-level reading comprehension tests in comparison to researcher's test using TM's	20 4th grade students in suburban elementary school	Quantitative: paired samples t-tests; Qualitative: evaluation of student-generated test items for cognitive level	Paired samples t-tests showed positive correlations between tests; showed significant improvement answering test questions developed by peers; Qualitative evaluation of test items showed ability to generate higher-order questions
Chang, K.E., Sung, Y.T., Chen, I.D. (2002)	Test the learning effects of concept mapping	126 5th grade students in elementary school in Taipei, Taiwan, 60 girls & 66 boys divided into 4 groups (3 experimental, 1 control)	Quantitative: one-way ANCOVA of post-test scores	Map-correction strategy worked significantly better than scaffold-fading & map-generation when post-hoc comparison using Bonferroni method used
DeCecco, V.M. & Gleason, M.M. (2002)	Examined if graphic organizers helped LD middle school students attain & retain information from expository texts	26 LD middle school students in 2 Oregon middle schools (1 low SES, 1 middle SES)	Quantitative: 2-way condition x test ANOVA with repeated measures, pre-test/post-test with control group; Woodcock Reading Mastery Test-Revised	Test subjects in both groups scored significantly higher on the post-tests (63% & 67%); Scheffe post hoc analysis showed significantly more relational knowledge with graphic organizer group than without graphic organizers

Gallagher, M.L. (2011)	Test to see if use of TM's improved students' ability to evaluate primary dietary literature	Students in Advanced Nutrition & Metabolism classes at East Carolina University	Qualitative: analysis of writing over each of 4 semesters; informal interviews on perceptions of ability to write	Use of TM's improved organization & clarity of writing over 4 semesters it was implemented; Students indicated they had better understanding of research process & were able to write about the 5 articles in more concise manner
Gibbs, S.L. (2009)	Test to see if reading achievement of third & fourth grade students who used TM's would improve	3rd & 4th graders in three schools in middle Tennessee over 5 years of implementation for 2 schools; 1 school with no treatment was used as a control	Quantitative: analysis of test scores on TCAP, independent sample t-tests; Qualitative: surveys on perceptions of TM's by teachers	Q1: no evidence that length of implementing TM's affected Rdg. Achievement, but showed increase in student scores; Q2: no evidence that implementing TM's affected Rdg. achieve-ment; Q3: well-established TM's program steadily improved scores vs. more recent implementation
Hester, J.P., Owen, S., Piekarski, B., & Hildebran, W. (1995)	Provide background and information on how Catawba Co. Schools developed & implemented the plan for integrating TM's into the curriculum	One school in Catawba Co., NC with low test scores; also Tuttle Middle School	Quantitative: analysis of test scores, no data in article	Test scores from first school demonstrated "outstanding" growth (no quantitative data); Tuttle MS had "upswing" in writing, reading, & other achievement test scores (no data)

Hickie, M.K. (2006)	Test to see if an association exists between TM's instruction & student achievement in 5th grade students in R/ELA & Math	70 students in 3 Title I elementary schools in Tennessee	Quantitative: paired t-tests, 3-factor repeated measures ANOVAs	Q1: results showed significant differences b/w 2003 & 2005 Reading means, no significant diff. in Math means; Q2: results showed no significant diff. in school or gender, but the mean for 2005 R/ELA scores was 8 points higher; Q3: results showed no significant diff. in school, gender, or year for Math; Q4: results showed significant diff. b/w 2003 & 2005 R/ELA means; Q5: results showed no significant diff. in interactions in school, year, or gender for Math
Hyerle, D.N. (1993)	1. To investigate the need for TM's. 2. Define the maps & explore practical use. 3. Present TM's as common visual language for organization, problem-solving, concept development, & thinking.	N/A	Non-empirical narrative with examples	Base research & development

Hyerle, D.N. (2000)	To aid readers in practical application of TM's	Reports gains in scores in different schools across U.S.	Quantitative: shows only gains in scores on assessments	Fain Elem., Atlanta, GA: 1996, Reading scores increased 29-69% & math increased 32-63% on GTBS; Friendship Valley Elem, Carroll County, MD: 1996, Writing rose 27%, Language increased 20%, Science rose 18% on MSPAP; Windemere Elem., West Orange County, FL: 1997 Math scores increased from 79-92%, Reading increased 68-80% on Stanford-8; Waitz Elem., Mission, TX: 1994 Math scores increased 41-76%, Reading increased 62-88% on TAAS

Hyerle, D.N. (2000), continued	To aid readers in practical application of TM's	Reports gains in scores in different schools across U.S.	Quantitative: shows only gains in scores on assessments	Claremont Elem., Catawba County, NC: 1993-1996 Writing scores increased from 33--68% at 4th grade on NC EOYT; Tuttle Middle, Catawba Co., NC: 1994-1996 Writing scores increased 43-73% at 8th grade on NC EOYT; Chadbourne Elem., Columbus Co., NC: 1993-1995 Writing scores increased from 35-60% on NC EOYT; Morrisville Elem., Wake Co., NC: 1993-1996 Writing scores increased from 32-76% on NC EOYT
Hyerle, D.N. (2000), continued	To aid readers in practical application of TM's	Reports gains in scores in different schools across U.S.	Quantitative: shows only gains in scores on assessments	Allen Elem., Cabarrus Co., NC: 1998 Reading scores increased from 77-89%, Writing scores increased from 29-77%, & Math scores increased from 80-91% on NC EOYT
Leary, S.F. (1999)	To study the effects of TM's on achievement in math, reading, & language	78 Fourth grade students	Quantitative: 3-way ANOVA analysis of Stanford -9 test scores; Qualitative: interviews with teachers	No significant difference between treatment & control on any of the variables (treatment vs. control, race, gender, previous achievement level)

Russell, L. (2010)	Explore the impact of TM's on reading comp. achievement	199 Fourth grade & 199 Fifth grade students	Quantitative: repeated measures ANOVA for variables socio-economic status, gender, ethnicity, & LEP; Qualitative: surveys for perceptions	No significant difference in reading achievement during 4th & 5th grade on the Texas Growth Index (socio-economic, ELP, gender, ethnicity); Repeated Measures ANOVA showed significant differences in TGI between 4th & 5th grade
Sunseri, A.B. (2011)	Study the effects of using TM's to generate expository writing with non-ELL & ELL students	71 Fourth grade students	Quantitative: analysis of rubric scores; Qualitative: interviews with students & classroom observations	No significant difference between treatment & control; small difference in ELL students' writing vs. non-ELL students' writing

CHAPTER THREE

METHODOLOGY

This chapter describes the methodology and procedures used in this study. The purpose of the study was to determine if the use of Thinking Maps® has an effect on students' academic achievement and to determine if teachers believe Thinking Maps® are effective in helping students learn science concepts at their grade level, with an assessment score of 800 or higher on the Georgia Criterion-Referenced Competency Tests. Additionally, the study investigated the potential relationship between teachers' beliefs about Thinking Maps® and their effectiveness for improving students' academic achievement in science. Previous research on Thinking Maps® has been conducted in elementary schools and colleges with mixed results. A few studies have been conducted in middle schools, some with students with learning disabilities. Much of the research conducted on Thinking Maps® has been conducted by Hyerle, the creator of Thinking Maps®, with the goal of establishing a connection between Thinking Maps® usage and improved test scores.

The research questions for the study were: (1) To what extent do Thinking Maps® affect middle grades students' academic achievement in science? (2) What are teachers' perceptions about the use of Thinking Maps® with middle grades students? (3) What, if any, is the relationship between the use of Thinking Maps® and teachers' perceptions and implementation in middle grades? Specifically, what changes or trends, if any, were evident in the science achievement of middle school students in classes that used Thinking Maps®?

Participants

This study took place in a suburban Title I school system comprised of eighteen schools in west central Georgia that serves nearly 10,500 students, with approximately 1100 staff members, in 2013 (Georgia Department of Education, 2013). There are eleven elementary schools, four middle schools with grades six through eight, and three high schools. The percentage of middle school students on free or reduced-price lunch in the 2012-2013 school year was 77.28% (Georgia Department of Education, 2013). The subjects for this study were students at the middle school level. During the 2012-2013 school year, the total population of middle school students in this system was 2667 (Georgia Department of Education, 2013). This means that over 2000 middle school students in this system are on free or reduced-priced lunch.

During the 2012-2013 school year, females comprised 49.36% of the total middle school population, with black females representing 47.46% and white females comprising 45.39% of the population. Hispanic females made up less than 5% of the population. Male middle school students in this system during the same school year comprised 50.64% of the total population. White males comprised 48.45% of the population, while black males comprised 43.24% of the middle school population. The subgroup of Hispanic males comprised a little over 5% of the population (see Table 1) (Georgia Department of Education, 2012).

Table 1

School System Ethnicity and Gender Data, 2012-2013

Gender	Ethnicity/Race	Grade 06	Grade 07	Grade 08	Total	%
Female	Hispanic	16	13	19	48	4.13
	American Indian	3	0	0	3	0.26

	Asian	5	2	1	8	0.69
	Black	180	195	176	551	47.46
	Pacific Islander	0	0	0	0	0
	White	193	169	165	527	45.39
	Two or More Races	7	9	8	24	2.07
	Subtotal	404	388	369	1161	49.36
Male	Hispanic	22	23	15	60	5.04
	American Indian	1	0	0	1	0.08
	Asian	3	3	3	9	0.76
	Black	168	175	172	515	43.24
	Pacific Islander	0	0	0	0	0
	White	190	208	179	577	48.45
	Two or More Races	8	8	13	29	2.43
	Subtotal	392	417	382	1191	50.64
	System Total	796	805	751	2352	

The student population during the 2013-2014 school year remained relatively static. The female population comprised 49.94% of the 2,352 total middle school students. Of the total, black females numbered 47.19% and white females numbered 43.61%. The number of Hispanic females increased to 59, which was 5% of the population. The population of males comprised 50.06% of the total population. During this school year, the gap in the number of black and white males closed slightly, with black males comprising 44.27% of the middle school population, and white males comprising 46.05% of the population. Hispanic males also increased to comprise 6% of the total population (see Table 2) (Georgia Department of Education, 2013).

Table 2

School System Ethnicity and Gender Data, 2013-2014

Gender	Ethnicity/Race	Grade 06	Grade 07	Grade 08	Total	%
Female	Hispanic	23	18	18	59	5.03
	American Indian	0	3	1	4	0.34
	Asian	8	5	2	15	1.28
	Black	188	175	191	554	47.19
	Pacific Islander	0	0	0	0	0
	White	156	195	161	512	43.61
	Two or More Races	13	8	9	30	2.56
	Subtotal	388	404	382	1174	49.94
Male	Hispanic	23	23	25	71	6.03
	American Indian	2	0	1	3	0.25
	Asian	4	3	5	12	1.02
	Black	180	170	171	521	44.27
	Pacific Islander	0	0	0	0	0
	White	157	187	198	542	46.05
	Two or More Races	10	9	9	28	2.39
	Subtotal	376	392	409	1177	50.06
	System Total	764	796	791	2351	

The teacher demographics of the school system showed a large number of highly-qualified teachers with a Master’s degree or higher. The majority of teachers in the system were female and white, with an experience level of less than twenty years.

The science department at one middle school in the district was selected for the current study. The demographics of this convenience sample showed a similar distribution to that of the district, where 92% of the science teachers or special education collaborative science teachers had a master’s degree or higher. Several of the teachers during the course of this study were

working on advanced degrees as well. Of the thirteen teachers who participated in this study, 84.61% of them were female, and the same percentage was white, while 15.39% were black. Nearly 62% of the science teachers had greater than ten years' experience (see Table 3).

Table 3

School System & Selected School PK-12 Teacher Demographics, 2012-2014

	2012-2013 System	2013-2014 System	Selected School Science Department*
Certificate Level			
4-Yr Bachelor's	242	214	1
5-Yr Master's	307	302	5
6-Yr Specialist's	104	116	5
7-Yr Doctorate	13	19	2
Certified Personnel			
Professional	654	638	13
Provisional	19	19	0
Gender			
Female	549	528	11
Male	124	129	2
Race/Ethnicity			
Asian	3	3	0
Black	197	204	2
Hispanic	11	10	0
Multiracial	11	12	0
Native American	0	0	0
White	451	428	11
Years' Experience			
<1	38	37	0
1-10	279	249	5
11-20	211	223	3
21-30	118	123	4
>30	27	25	1

Note: Selected School Science Department retained the same personnel over the course of the study

Instruments

Teacher Survey.

A researcher-created survey was used to determine teachers' perceptions about the use of Thinking Maps® with middle grades students under the supervision of a university faculty member specializing in science education, and a panel of experts evaluated it prior to the study. Specifically, the survey was aimed at finding out the level of usage by teachers, if teachers believe Thinking Maps® help improve their students' achievement in science, and if they believe Thinking Maps® are effective in helping students learn science concepts and contribute to students scoring in the "exceeds expectations" category (i.e., greater than 800) on the Georgia CRCT in science at their grade level.

According to Trochim (2006), researchers use surveys to aid in the triangulation of data. Surveys serve to give the researcher either a wider view of the population's perceptions, beliefs, or views, or a narrower view, which can then lead to more in-depth probing and information access. Surveys may yield better participation. Respondents may be quicker to complete a survey and be more honest, give short, concise answers, and may provide detail to open-ended questions due to greater privacy. Using surveys, the researcher can better understand teachers' perceptions of Thinking Maps®. Surveys of teachers were conducted to evaluate their use of Thinking Maps® in their classes (see Appendix).

Georgia Criterion-Referenced Competency Test (CRCT) science test scores for 2012-2013 and 2013-2014 were obtained and analyzed, along with usage and beliefs data from the survey, using the IBM Statistical Package for the Social Sciences version 24 for Windows

(SPSS) and the SAS Institute's Statistics Analysis Software (SAS/STAT®) statistical analysis software packages.

Research question one: To what extent do Thinking Maps® affect middle grades students' academic achievement in science?

Research question two: What are teachers' perceptions about the use of Thinking Maps® with middle grades students?

Research question three: What, if any, is the relationship between the use of Thinking Maps® and teachers' perception and implementation in the middle grades? It considered the existence of a relationship between the use of Thinking Maps® and changes, or trends, in the science achievement of students in middle grades who used Thinking Maps®.

According to the Standards for Educational and Psychological Testing (1999), validity is defined as "the degree to which evidence and theory support the interpretations of test scores entailed by proposed use of tests" (p. 9). The Georgia Department of Education developed the Criterion-Referenced Competency Tests with validity by using a multi-tiered process that began with the curriculum for each grade level, in which teams of educators established a test blueprint and test specifications for how the standards would be assessed. From the blueprint and specifications, the content domain specifications were developed to separate specific standards into strands or domains. Then, test item specifications were generated to give the item format, content scope limits, and cognitive complexity for the test items for the test items that were to be written. When complete, this working document is then called CRCT Content Descriptions. At this point, professional assessment specialists wrote test items as described in the content descriptions and in the content weights for each domain. Teams of educators reviewed the test items for curriculum alignment, potential bias, cultural or gender sensitivity, and suitability, then

revised, edited, or rejected items as needed. Then the items were placed on field tests or as items on operational tests. Once items were field tested, educators conducted data analyses to see if the items had any biases and revised, edited, or rejected test questions again. The questions that were accepted were then placed on an item test bank for future inclusion on an operational test.

The standards of testing, as established by the American Educational Research Association, the American Psychological Association, and the National Council on Measurement in Education, defined reliability as "the degree to which test scores for a group of test takers are consistent over repeated applications of a measurement procedure and hence are inferred to be dependable, and repeatable for an individual test taker; the degree to which scores are free of errors of measurement for a given group" (p. 180). Reliability coefficients are estimated values that fall between 0 and 1 (Trochim, 2006). The closer to 1 the coefficient falls, the more reliable the instrument. The reliability for the both the 2012-2013 and 2013-2014 CRCT was 0.92 for sixth grade, 0.94 for seventh grade, and 0.92 for eighth grade (see Table 4).

Table 4

CRCT Reliability Coefficients for Science by Grade, 2013 and 2014

Grade	2013		2014	
	Alpha	SEM	Alpha	SEM
6	0.92	3.28	0.92	3.31
7	0.94	3.01	0.94	3.00
8	0.92	3.28	0.92	3.24

Note. Alpha = Cronbach's alpha; SEM = Standard Error of Measurement

Research Design

This research study utilized a mixed-methods design. It used both primary and secondary data sources. The primary data consisted of Georgia Criterion-Referenced Competency Tests science test scores, and the secondary sources of data included survey data and interview data from teachers on their perceptions about the use of Thinking Maps® to aid students in learning science content. According to the National Institutes of Health Office of Behavioral and Social Sciences Research (2015), mixed-methods research is one "employing rigorous quantitative research assessing magnitude and frequency of constructs and rigorous qualitative research exploring the meaning and understanding of constructs" (p. 4). Descriptive research involves gathering data that describe events and then organizes and describes the collected data (Glass & Hopkins, 1984). This study used a concurrent triangulation mixed-methods research design (Creswell, 2003). The quantitative data were from two sequential school years, 2012-2013 and 2013-2014. However, these data were not analyzed prior to the collection of the survey and interview data. Rather, the quantitative and qualitative data were analyzed concurrently to triangulate the data.

Quantitative data for this study consisted of CRCT scores for the 6^{th}, 7^{th}, and 8^{th} grade students at the selected school for the 2012-2013 and 2013-2014 school years. These data were collected by the school at the end of each school year; however, scores for this study were obtained by the researcher as a part of the research process following approval by the Institutional Review Board (IRB). This study was classified as exempt and permission to begin data collection was received on September 6, 2016. Thinking Maps® usage data from the teacher survey were quantified for the purpose of analysis. All physical copies of data and materials, from notes, printouts, SPSS/SAS output, surveys, and portable storage devices, will be stored in a locked file cabinet off campus with the researcher for a minimum of three years.

Qualitative data for this study came from the open-ended questions on the teacher survey. These data were used to triangulate and expand upon the quantitative analyses.

Data Collection

Middle grades science teachers were surveyed regarding their perceptions and use of Thinking Maps® (see Appendix). The researcher developed the survey with the direct assistance of a faculty member from the researcher's university who specialized in science education. Faculty at the selected school were apprised of the study and informed that participation was voluntary prior to distribution of the survey. When it was determined that only the science department and those special education teachers who taught science should be the focus of the survey, those teachers were informed verbally prior to dissemination of the surveys. All six of the regular education science teachers, six special education collaborative science teachers, and one gifted education teacher were surveyed at the selected school, and all 13 members of the science department participated.

Science scores for students from the 2012-2013 and 2013-2014 administrations of the Georgia Criterion-Referenced Competency Tests were obtained from the assistant principal for instruction at the selected school from the copy received from the Georgia Department of Education that included only the students' student number and achievement score. The researcher developed a spreadsheet of the scores in preparation for analysis using the IBM Statistical Package for the Social Sciences version 24 (SPSS) and the SAS Institute's Statistics Analysis Software (SAS/STAT®) statistical analysis software packages to see if there was a difference in the scores of those using Thinking Maps® systematically and consistently and those not using Thinking Maps® systematically and consistently.

Procedures

In this study, teachers were surveyed on their perceptions and beliefs about Thinking Maps® and if they believe Thinking Maps® increase their students' science achievement. Teachers were surveyed regarding the amount of use of Thinking Maps® in their classes, which maps they used the most, if they believe Thinking Maps® are effective and help students learn science concepts, which maps they believe are least effective, how Thinking Maps® are used in their classes, and if they believe Thinking Map® achieve the projected outcomes (i.e., improved science scores on the CRCT).

Data Analysis

The data collected from teacher surveys were analyzed for the subject area, grade, number of years using Thinking Maps®, and if teachers believed Thinking Maps® help students learn science. Two of the questions had both a finite answer and an open-ended part. Four of the questions were open-ended and were analyzed and the responses categorized using open coding, a process by which qualitative data is broken down and categorized by certain behaviors to discover what it means (Benaquisto, 2008). Survey data from teachers participating in the study were analyzed for the number of times Thinking Maps® were used in a day/week and classes, which were used the most, which were the least/most effective, which the teacher believed helps students learn better, and if the teacher believed Thinking Maps® achieve the intended outcome. Two of the questions included an open-ended part, and one question was completely open-ended. Open coding was used to analyze and categorize the open-ended questions.

Students who received instruction using Thinking Maps® in a systematic and consistent manner were included in the group using Thinking Maps®, and those students who did not receive instruction with Thinking Maps® in a systematic and concise manner were included in the non-usage group. The Thinking Maps® usage was determined by the teacher surveys. Using Thinking Maps® at least 3 days a week and at least once per class was considered systematic and consistent usage, any usage less frequent than this was considered non-systematic and non-consistent usage.

This study also focused on the teachers' perceptions and beliefs about the Thinking Maps® and their use at the 6-8 grade levels in science. Teacher perception surveys and the analysis of CRCT scores in science were used for the two groups to determine if there was a relationship between the achievement scores and the teachers' perceptions and beliefs as to the efficacy of the Thinking Maps® program.

Lastly, science scores for students from the 2012-2013 and 2013-2014 administrations of the Georgia Criterion-Referenced Competency Tests were analyzed using SPSS and SAS to determine if there was a difference in the scores of those using Thinking Maps® and those not using Thinking Maps®. Science achievement scores were analyzed using appropriate statistical analysis using SPSS and SAS/STAT depending on the skewness and kurtosis values. Test scores were compared at their respective grade levels for consistent and systematic use of Thinking Maps® and those without consistent and systematic use of Thinking Maps®. Then, aggregated scores in each usage group were analyzed along with the teacher surveys to determine if a relationship existed between use of Thinking Maps® and teacher perceptions and implementation of Thinking Maps®. A relationship that correlates the teacher's belief that Thinking Maps® used consistently and systematically help students learn science with favorable

test scores could make a strong case for evidence that Thinking Maps® helped increase students' science achievement. Conversely, a relationship that did not correlate the teacher's belief that Thinking Maps® not used consistently and systematically help students learn science with unfavorable test scores could make a strong case for evidence that Thinking Maps® do not help students' science achievement. Because the CRCT scores are quantitative data and the teacher surveys include qualitative data, a relationship may be determined by a teacher believing in and consistently using Thinking Maps® and having high achievement scores on the CRCT. The opposite could be true as well. The results of an analysis of variance in the test scores may indicate the relationship between high scores and usage.

Test score data for students' science scores from the 2012-2013 and 2013-2014 administrations of the CRCT were analyzed first to determine if a statistically significant difference in CRCT scores of classes using Thinking Maps® and those classes not using Thinking Maps®. Then, scores of those classes using Thinking Maps® were analyzed using non-parametric, one-way ANOVA with the use of Thinking Maps® as the independent variable, CRCT scores as the dependent variable. This paired with the survey data will help to determine if there is a relationship between the use of Thinking Maps® and teachers' implementation and perceptions, as measured by CRCT science scores.

Summary

This study examined the effects of Thinking Maps® on the achievement of middle school students in science. Data consisted of surveys of teachers on their perceptions and implementation of Thinking Maps®, if they believed the maps help their students learn, and their use of Thinking Maps® in their classrooms. Science achievement scores from the 2013 and

2014 spring administrations of the Georgia Criterion-Referenced Competency Tests (CRCT) were analyzed using a non-parametric, one-way ANOVA using the SPSS and SAS/STAT data analysis software packages. The results were analyzed to determine if there is a relationship between the use of Thinking Map® and teachers' beliefs and perceptions, as measured by CRCT science achievement scores.

CHAPTER FOUR

RESULTS

The purpose of this study was to determine if the use of Thinking Maps® has an effect on students' academic achievement and to determine if teachers believe Thinking Maps® are effective in helping students learn science concepts at their grade level, with an assessment score of 800 or higher on the Georgia Criterion-Referenced Competency Tests. Additionally, the study investigated the potential relationship between teachers' beliefs about Thinking Maps® and their effectiveness for improving students' academic achievement in science. The research questions driving this were: (1) - To what extent do Thinking Maps® affect middle grades students' academic achievement in science? (2) - What are teachers' perceptions about the use of Thinking Maps® with middle grades students? (3) - What, if any, is the relationship between the use of Thinking Maps® and teachers' perception and implementation in middle grades? Specifically, what changes or trends, if any, were evident in the science achievement of middle school students in classes that used Thinking Maps®?

To answer the first question, standardized test scores from the Georgia Criterion-Referenced Competency Tests (CRCT) in science for grades six through eight were analyzed for differences in the scores based on the usage or non-usage of Thinking Maps® in the science classes. Three teachers, one at each level (6th, 7th, and 8th grades), used Thinking Maps® frequently in their practice, and three teachers did not use Thinking Maps® in their practice.

The second question investigated teachers' perceptions about using Thinking Maps® with their middle grades science classes. This information was gathered by surveying science teachers. The survey asked in which branch of science, earth; life; or physical, the teacher used or did not use Thinking Maps®, if they received training in Thinking Maps®, if they believe Thinking Maps® helps their students learn science, and which Thinking Maps® they believe are most effective and least effective. Teachers were also asked, through the survey, which Thinking Maps® they used the most if they used them, how often they used Thinking Maps® if they used them, how they used them in their classes if they used them, and if they believe Thinking Maps® achieve their designated outcome in learning science content. Additionally, teachers' demographic information was collected.

The third research question considered the existence of a relationship between the use of Thinking Maps® and the teachers' perceptions of the effectiveness of Thinking Maps®, and if changes or trends in the achievement of students in middle grades were evident for those who used Thinking Maps®.

This chapter is divided into three sections: analysis of student test score data, analysis of teacher survey data, and exploration of a possible relationship between the use of Thinking Maps® and students' test scores. The first section analyzes demographic data and the science test scores from the 2012-2013 and 2013-2014 administrations of the Georgia Criterion-

Referenced Competency Tests (CRCT) for non-usage or usage of Thinking Maps® across the three grade levels. The second section analyzes responses from science teachers regarding their use and perceptions of Thinking Maps®. It includes demographic data, which may be used to determine if age or experience play a factor in the use or perception of Thinking Maps®. The third section will discuss if there is a relationship between the use of Thinking Maps® and students' test scores.

Data Analysis

Descriptive Statistics, 2012-2013

Sixth, seventh, and eighth grade students from a Title I middle school located in a suburban school district in middle Georgia provided the sample and focus of this study. Scores for 702 students for the 2012-2013 were separated into two groups: (a) Students who did not use Thinking Maps® instruction in the classroom and (b) Students who did use Thinking Maps® instruction in the classroom. Non-parametric tests were conducted.

Table 1 provides information on descriptive statistics of CRCT scores based on usage or non-usage of Thinking Maps®. For the 2012-2013 CRCT science test administration overall scores, there were a total of 702 students, with 349 students in the Non-Thinking Maps® or non-usage instructional group, which was 49.72% of the total students tested, and 353 students comprising the Thinking Maps® or usage instructional group, which was 50.28% of the total students tested. In the non-usage group, the mean CRCT score was 825.94 (n=349, SD=36.500), and the mean CRCT score for the usage group was 822.98 (n=353, SD=33.202) (see Table 1). The difference in means was 2.96. Overall, CRCT scores were higher for the non-usage group,

or those who did not use Thinking Maps®, than the usage group or those who used Thinking Maps®.

There were 130 sixth grade students, or 50.39% of the total number of sixth graders, who were in the non-usage group, and 128 sixth grade students, or 49.61%, who were in the usage group. Together the sixth grade comprised 36.75% of the total number of students tested on the science CRCT. Of the 224 seventh grade students tested, 108 of them, or 48.21%, were in the non-usage group, while 116, or 51.79%, were in the usage group. Seventh graders comprised 31.91% of the total number of students tested. There were 111 eighth grade students, or 50.45% of the total number of eighth graders, in the non-usage group, and 109 students, or 49.55% of the students tested, in the usage group. The eighth graders made up 31.34% of the total number of students tested on the science CRCT (see Table 2).

Table 2 presents descriptive statistics of the CRCT science test scores by grade level. For the 2012-2013 CRCT test administration, there was a total of 258 sixth grade students, comprising 36.75% of the total students being tested. The mean CRCT score for the sixth grade was 821.54 (m=258, SD=30.733). There was a total of 224 seventh grade students, making up 31.91% of the tested population. The mean CRCT score for the seventh grade was 839.00 (m=224, SD=34.752). There was a total of 220 eighth grade students, comprising 31.34% of the tested population. The mean CRCT score for the eighth grade was 813.05 (m=220, SD=34.651). The difference between the means measured 17.46 between the sixth and seventh grades and 25.95 between the seventh and eighth grades. The average difference between the means was 21.705 (see Table 2). This showed the seventh grade having a marked difference in means from the sixth and eighth grade groups.

The National Institute of Standards and Technology at the U.S. Department of Commerce defines a confidence interval as a range that "would bracket the true population parameter in approximately 95% of the cases" if sampled on multiple occasions (NIST, 2013). This means that if we sampled the population in a different year, each grade would yield achievement scores that fell within the confidence interval for the same teachers. The sixth grade results show a mean of 840.13 (n=130, SD=28.611) for the non-usage group, and a mean of 802.66 (n=128, SD=19.156) for the usage group, the non-usage group showing a 37.47 point difference. The difference between the upper bound and lower bound scores in the 95% confidence interval for the sixth grade was 9.93 for the non-usage group and 6.70 for the usage group. The seventh grade non-usage group scored a mean of 840.65 (n=108, SD=37.545), and the usage group had a mean of 837.46 (n=116, SD=32.022). The mean scores for the non-usage and usage groups were closer in the seventh grade, but the non-usage group still scored higher than the usage group. The difference in the seventh grade confidence intervals was 14.32 for the non-usage group and 11.78 for the usage group, a difference of 2.54. The non-usage group in the eighth grade scored a mean of 795.00 (n=111, SD=21.614), and the usage group scored a mean of 831.42 (n=109, SD=35.824). Contrary to the other two grades, the eighth graders who used Thinking Maps® scored an average of 36.42 points higher than the non-usage group. The difference in the eighth grade confidence intervals was 8.14 for the non-usage group and 13.60 for the usage group, a difference of 5.46. The mean CRCT scores were approximately the same for the sixth and seventh graders who did not use Thinking Maps®, but the eighth grade students who did not use Thinking Maps® scored much lower than their usage counterparts, with a mean of 795.00 (see Table 2).

Table 1

Descriptive Statistics, Usage & Non-Usage of Thinking Maps®, 2012-2013 Science CRCT

Group Statistics

		N	Mean	SD	SE Mean	Skewness	Kurtosis
Score	Non-usage	349	825.94	36.500	1.954	0.342	-0.202
	Usage	353	822.98	33.202	1.767	0.778	0.895

Note. N = sample size; SD = standard deviation; SE = standard error

Table 2

Descriptive Statistics by Non-Usage and Usage, 2012-2013 Scores by Grade Level

	6th Grade			7th Grade			8th Grade		
	Non-Usage	Usage	Total	Non-Usage	Usage	Total	Non-Usage	Usage	Total
N	130	128	258	108	116	224	111	109	220
% Total Tested	50.39	49.61	100.00	48.21	51.79	100.00	50.45	49.55	100.00
Mean	840.13	802.66	821.54	840.65	837.46	839.00	795.00	831.42	813.05
SD	28.611	19.156	30.733	37.545	32.022	34.752	21.614	35.824	34.651
SE	2.509	1.693	1.913	3.613	2.973	2.322	2.052	3.431	2.336
Skewness	0.175	0.015		0.208	0.077		0.241	0.929	
SE	0.212	0.214		0.233	0.225		0.229	0.231	
Kurtosis	0.101	-.760		-0.116	-0.419		-0.442	1.59	
SE	0.422	0.425		0.461	0.446		0.455	0.459	
95% CI Upper Bound	845.10	806.01		847.81	843.35		799.07	838.22	
Lower Bound	835.17	799.31		833.49	831.57		790.93	824.62	
Non-Usage Total	349								
Usage Total	353								

Note. N = sample size; SD = standard deviation; SE = standard error; CI = confidence interval.

Tests of Normality, 2012-2013

According to Field (2009), skewness is defined as the "lack of symmetry" in the distribution of variables. Data was aggregated by non-usage/usage and then by grade level. The histogram for the non-usage group showed a positive or right-skewed non-normal distribution with a skewness of .342 (SE = .131), while the histogram for the usage group also showed a positive or right-skewed non-normal distribution of .778 (SE = .130). Additionally, kurtosis is defined as "the degree to which scores cluster at the ends of the distribution" (Field, 2009). Westfall (2014) stated kurtosis "measures the departure from normality." The non-usage group had a negative kurtosis of -.202 (SE = .260). The usage group had a positive kurtosis of .895 (SE = .259). From this, we see the magnitude of kurtosis is higher for the usage group. This indicated that both distributions vary from normal distribution (see Figure 1 and 2). The Shapiro-Wilk test was conducted to test whether the CRCT test scores for the non-usage and usage groups departed from normality to a statistically significant degree. A significant test ($p < .05$) indicates the CRCT scores depart from normality, whereas a non-significant test ($p > .05$) indicates the scores follow a normal distribution. The Shapiro-Wilk test for each of the non-usage and usage groups, was significant, indicating the scores departed from normality (all *p*'s < .05), which gives evidence that we can reject the null hypothesis (see Table 3). Levene's test for homogeneity of variances for the non-usage group versus usage group was used to determine that variances in the data set were equal when the data exhibited a non-normal distribution. Tests for homogeneity of variances showed $F(1,700) = 6.230$, $p = .013$, which was not statistically significant because $p < .05$, indicating that the differences in CRCT science test scores across the grade levels is equal to a statistically significant degree, and it can be concluded there are unequal variances in the sixth, seventh, and eighth grades (see Table 4).

Figure 1

Histogram of Science CRCT Scores, Non-Usage, 2012-2013

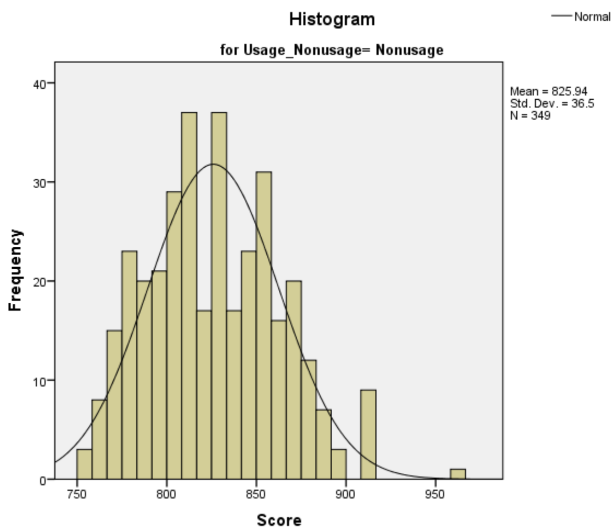


Figure 2

Histogram of Science CRCT Scores, Usage, 2012-2013

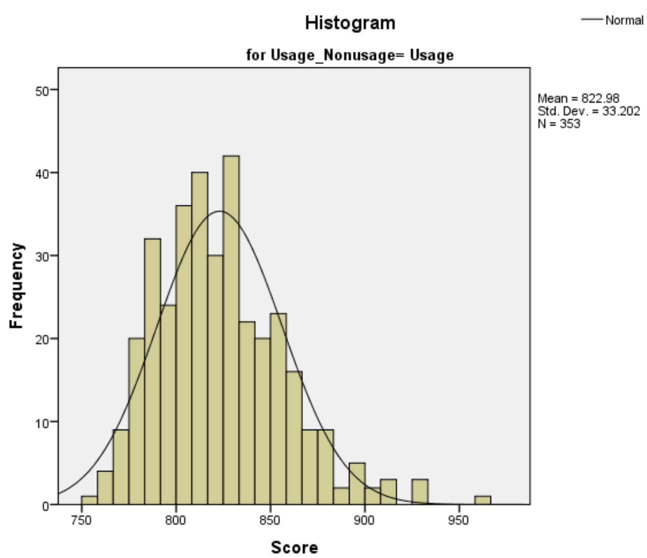


Table 3

Tests of Normality for Non-Usage and Usage, 2012-2013

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Non-Usage	0.061	349	0.003	0.985	349	0.001
Usage	0.070	353	0.000	0.966	353	0.000

a. Lilliefors Significance Correction

Table 4

Levene's Test for Homogeneity of Variance, Non-Usage and Usage, 2012-2013

Score	Based on Mean	6.230	1	700	0.013
	Based on Median	6.443	1	700	0.011
	Based on Median and with adjusted df	6.443	1	699.885	0.011
	Based on trimmed Mean	6.509	1	700	0.011

The histogram for the sixth grade reported a mean of 821.54 (n=258, SD=30.733) and showed a skewness of .508 with a standard error of .152, and a platykurtic kurtosis of .035 with a standard error of .302, showing a non-normal distribution (see Figure 3). The histogram for the seventh grade reported a mean of 839.00 (n=224, SD=34.752) and showed a skewness of .178 with a standard error of .163, and a kurtosis of -.159, also platykurtic, with a standard error of .324, showing a non-normal distribution (see Figure 4). The histogram for the eighth grade reported a mean of 813.05 (n=220, SD=34.651) and showed a skewness of 1.072 with a standard error of .164, and a kurtosis of 2.057, also platykurtic, with a standard error of .327, showing a non-normal distribution (see Figure 5). Normality was supported by the Shapiro-Wilk test for

non-usage and usage for the sixth and seventh grades and only the non-usage group for the eighth grade because $p > .05$. Normality was supported by the Shapiro-Wilk test for only the usage group for the eighth grade, because $p < .05$ (see Table 5). Levene's test for homogeneity of variances for grade level versus non-usage/usage was used to determine that variances in the data set were equal when the data exhibited a non-normal distribution. Tests for homogeneity of variances showed $F(2,699) = 1.819$, $p = .0163$, which was statistically significant because $p >$ .05, indicating there is a difference between the grade levels to a statistically significant degree because the test is significant (see Table 6). We reject the null hypothesis, which states "there is no statistically significant difference in the variances of CRCT science test scores between grade levels," and it can be concluded there are unequal variances in the sixth, seventh, and eighth grades.

Figure 3

Histogram of Sixth Grade CRCT Scores, 2012-2013

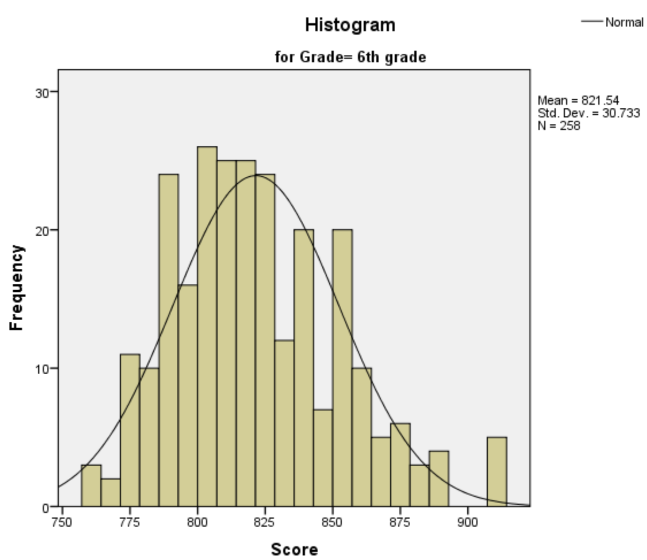


Figure 4

Histogram of Seventh Grade CRCT Scores, 2012-2013

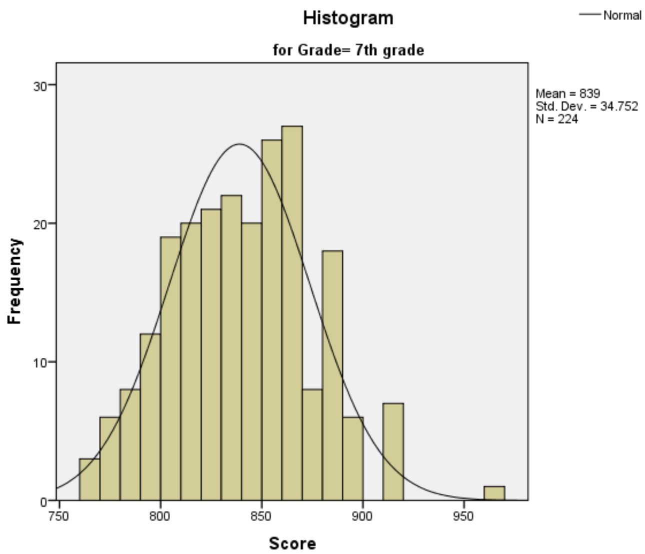


Figure 5

Histogram of Eighth Grade CRCT Scores, 2012-2013

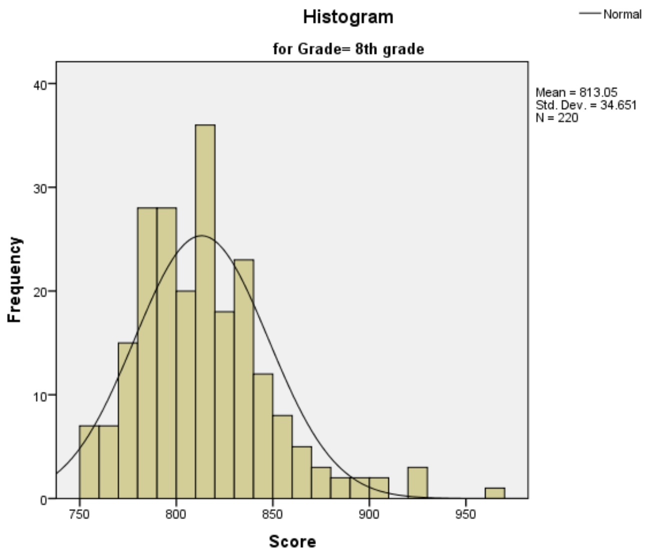


Table 5

Tests of Normality for Sixth, Seventh, and Eighth Grade, 2012-2013

Tests of Normality

Level	Non-Usage Usage	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
6	Non-Usage	.055	130	.200	.988	130	.308
	Usage	.088	128	.016	.984	128	.125
7	Non-Usage	.058	108	.200	.986	108	.324
	Usage	.058	116	.200	.988	116	.387
8	Non-Usage	.078	111	.097	.982	111	.137
	Usage	.103	109	.006	.950	109	.000

a. Lilliefors Significance Correction

Table 6

Levene's Test of Homogeneity of Variance, Grades 6, 7, and 8, 2012-2013

		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	1.819	2	699	0.163
	Based on Median	1.816	2	699	0.163
	Based on Median and with adjusted df	1.816	2	677.064	0.163
	Based on trimmed Mean	1.882	2	699	0.153

Transformations, 2012-2013

The Shapiro-Wilk and Kolmogorov-Smirnov normality tests indicated the scores for the non-usage of Thinking Maps® and the usage of Thinking Maps® groups were significant for both groups, so there was a need to transform the scores to reach a normal distribution. The scores did not follow a normal distribution even after transformations. However, because of the non-normal distribution shown in Figures 1 and 2, it was necessary to perform a non-parametric version of the independent *t*-test. An examination of skewness (sixth = .508; seventh = .178; eighth = 1.072), kurtosis (sixth = .035; seventh = -.159; eighth = 2.057), and standard deviations (sixth = 30.733; seventh = 34.752; eighth = 34.651) for the three grade levels and a visual examination of the histograms revealed the scores departed from normal, indicating a need to transform the scores to reduce the variance in the data. In addition, the Shapiro-Wilk and Kolmogorov-Smirnov normality tests were significant, which further warranted a need to apply the appropriate transformations on the CRCT scores so they more approximately followed a normal distribution and fulfilled the assumption of parametric statistical analysis. Therefore, a log e transformation was completed for the three grade levels. Because there were two levels,

non-usage and usage, a Mann-Whitney test was performed. Also, because there were three grade levels, a non-parametric version of the ANOVA was performed.

Non-Parametric Analysis, 2012-2013

The CRCT scores followed a non-normal distribution. The Kruskal-Wallis test is a rank-based non-parametric test, also known as the rank-based one-way ANOVA, that determines whether the CRCT scores that have been sampled from the entire population of CRCT scores originate from the same distribution. The independent variables were categorical, having three or more categories (sixth, seventh, and eighth grades), and the dependent variable was not normally distributed among the CRCT scores. The statistical tests constructed for data following a non-normal distribution needed to be ranked because these tests make fewer assumptions about the data, unlike the parametric tests. Therefore, the CRCT scores were first converted to ranked scores and then used in the Kruskal-Wallis test. The mean CRCT scores for the sixth, seventh, and eighth grades were 821.54, 838.45, and 813.05, respectively.

All non-parametric statistical analysis was conducted in SAS. The PROC NPAR1WAY is an in-built procedure in the SAS library to perform non-parametric analyses. PROC NPAR1WAY provides a summary of Wilcoxon-ranked scores for CRCT scores by each grade level, and the Kruskal-Wallis test. The Kruskal-Wallis tests the hypothesis that samples come from identical populations, that is the mean ranks of the groups are the same. The CRCT scores from the sixth, seventh, and eighth grades have equal-ranked mean scores. Therefore, the Kruskal-Wallis test was significant when the ranked mean CRCT scores between the sixth, seventh, and eighth grades are different from each other to a statistically significant degree, indicating that the CRCT scores of the three grade levels come from different populations. Table

7 shows that the mean CRCT-ranked scores were different from each other with seventh grade having the highest CRCT-ranked mean score with 437.16, followed by the sixth grade with 336.88, and eighth grade with 280.22.

The Kruskal-Wallis test was significant ($\chi^2 = 68.5175$, $p < .01$). Grade level had an effect on the CRCT scores to a statistically significant degree (see Table 8). There is sufficient evidence to reject the claim that CRCT-ranked mean scores from the three grade levels have equal-ranked mean scores. At least one of the ranked mean CRCT scores in one grade level appeared to be different from the other two grade levels. The Wilcoxon rank-sum test also depicted the same picture as the Kruskal-Wallis test where not only the sum of scores was above the standard deviation of H_0 but also the ranked mean score was different across grade levels, with the seventh grade having the highest CRCT-ranked mean score of 437.16. Therefore, the CRCT mean scores as well as the ranked mean scores was influenced most by the seventh grade, followed by the sixth grade and the eighth grade. That is, the seventh grade explains the most variance in CRCT scores when compared to the sixth and eighth grades. The distribution of CRCT-ranked sum scores in the box plot graphically depicts large differences in the lower quartile, middle quartile, and upper quartile scores based on grade levels (see Figure 6). The frequencies bar graph shows that seventh grade had a higher frequency of CRCT scores above the median than below the median, followed by the sixth and eighth grades (see Figure 7).

Table 7

NPAR1WAY Wilcoxon Results by Grade Levels, 2012-2013

Wilcoxon Scores (Rank Sums) for Variable CRCT

Classified by Variable Grade

Grade	N	Sum of Scores	Expected Under H_0	Std Dev Under H_0	Mean Score
8	220	61649.00	77220.00	2487.63091	280.222727
7	223	97486.00	78273.00	2496.71199	437.156951
6	258	86916.00	90558.00	2585.31688	336.883721

Average scores were used for ties.

Table 8

Kruskal-Wallis One-Way Test Results by Grade Levels, 2012-2013

Kruskal-Wallis Test	
Chi-Square	68.5175
DF	2
Pr > Chi-Square	<.0001

Figure 6

Wilcoxon Box Plot Scores for CRCT by Grade Level, 2012-2013

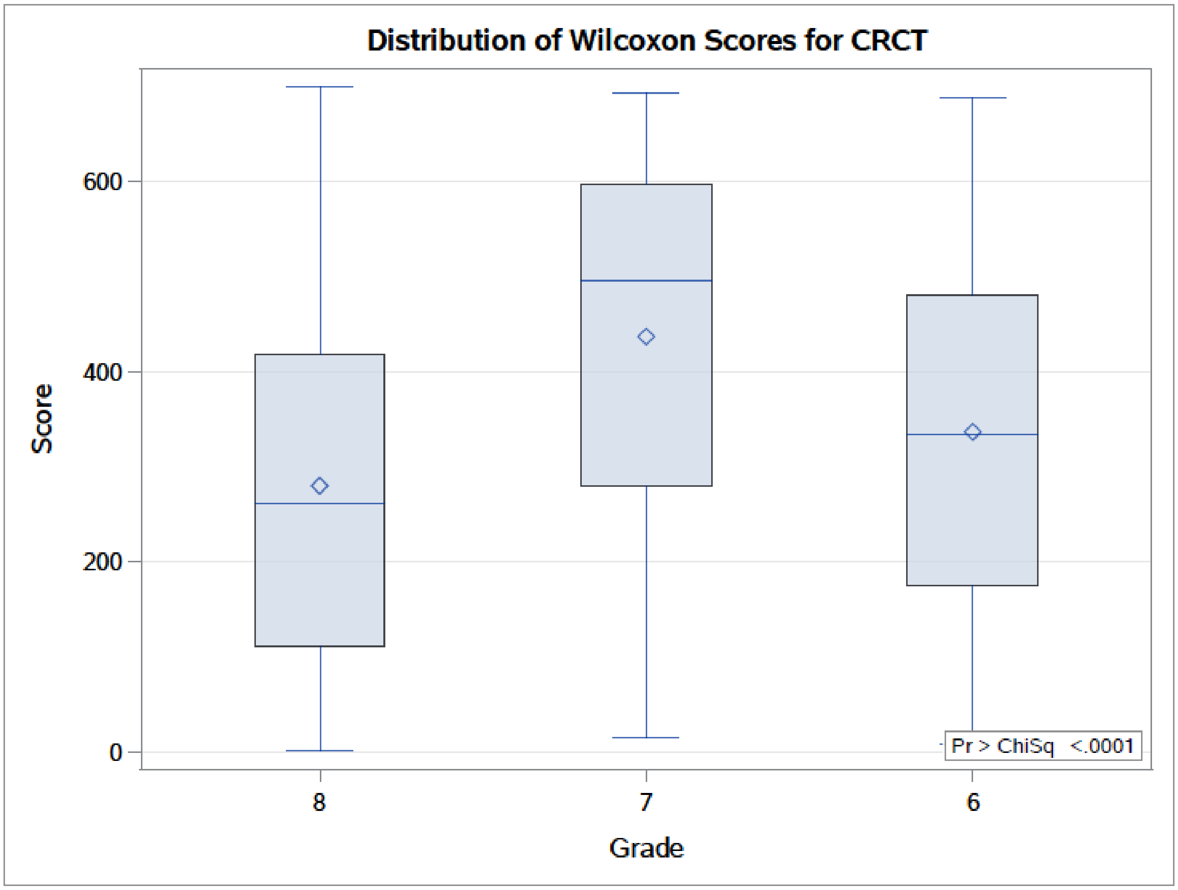
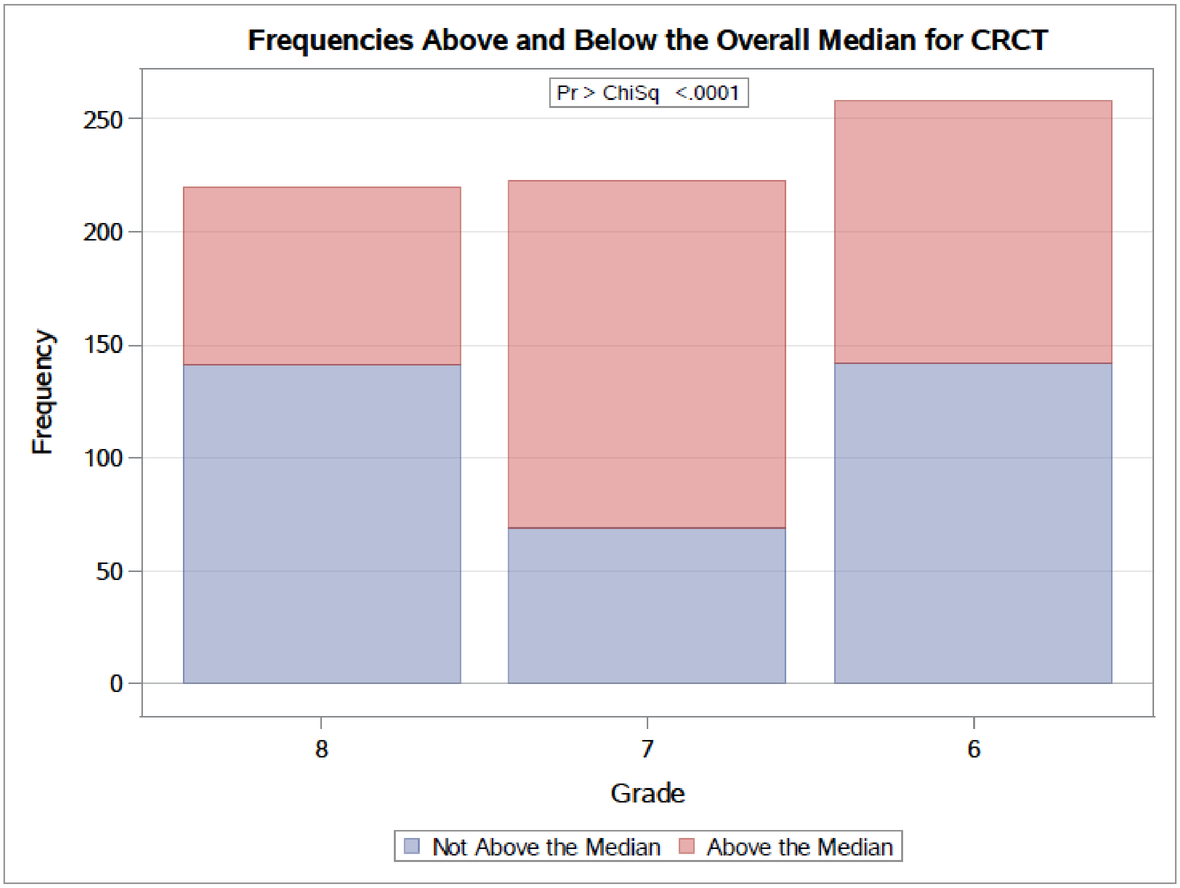


Figure 7

Frequencies Above & Below the Median CRCT Scores by Grade Level, 2012-2013



The asymptotic p-value for the Kolmogorov-Smirnov test was 3.9571, which indicates a rejection of the null hypothesis that CRCT score distributions were identical for the three grade levels (see Table 9). The empirical distribution of the CRCT scores were derived from the true distribution of CRCT scores. The empirical distribution graph of the CRCT scores showed the proportion of scores falling in the CRCT score ranges (see Table 10). The graph shows that the variation in the distribution of CRCT scores across the three grade levels was different but the magnitude of difference was much more in the seventh grade when compared to the sixth and eighth grades. The CRCT score ranges are on the X-axis and the proportion of CRCT scores fell in a range marked on the Y-axis. The graph shows that there was more variation in the seventh grade curve of CRCT score distribution, especially after the curve cross the 850 mark (indicated

by a steeper curve) when compared to the sixth and eighth grades and a graduation variation in the eighth grade curve (see Figure 8).

Table 9

Kolmogorov-Smirnov Asymptotic Statistics, 2012-2013

KS	0.14946	KSa	3.957176

Table 10

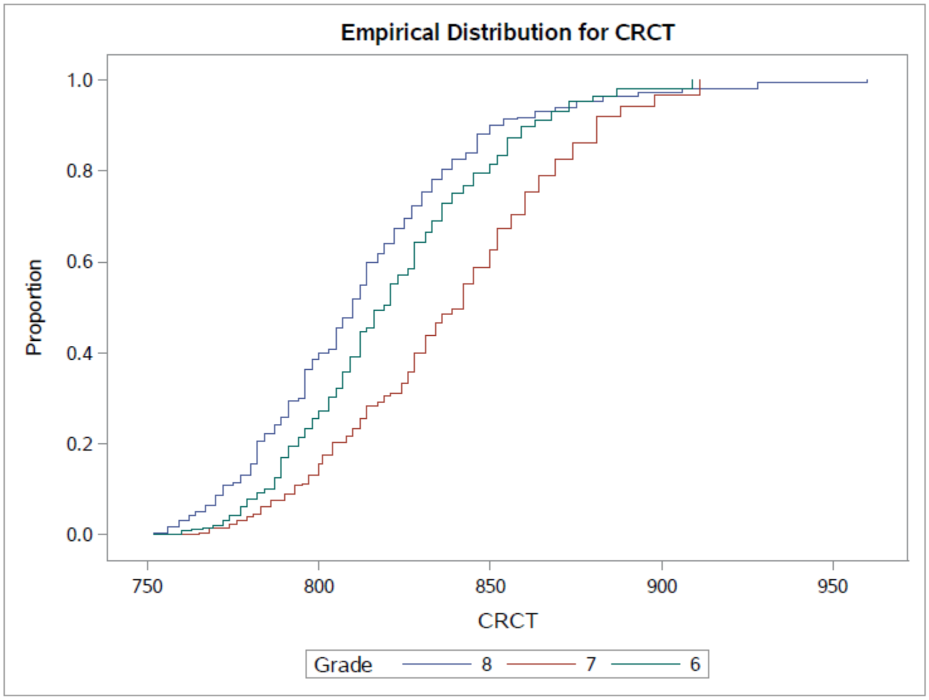
Kolmogorov-Smirnov Empirical Distribution Test by Grade Level, 2012-2013

Kolmogorov-Smirnov Test for Variable CRCT Classified by Variable Grade			
Grade	N	EDF at Maximum	Deviation from Mean at Maximum
8	220	0.672727	2.276314
7	223	0.309417	-3.133597
6	258	0.569767	0.811299
Total	701	0.519258	

Note. EDF = Empirical Distribution Function

Figure 8

Empirical Distribution Graph for CRCT Scores by Grade Level, 2012-2013



The Wilcoxon two-sample test is the non-parametric version of a t-test and is used to determine whether two samples were derived from a population having the same distribution. The two-sample test was utilized to determine the influence of non-usage and usage of Thinking Maps® on the variation in CRCT scores. The mean CRCT score for non-usage and usage groups was 822.98 and 825.94, respectively. The Wilcoxon mean-ranked CRCT scores for non-usage (coded as 1) was 361.02 and for usage (coded as 2) was 342.09 (see Table 11).

The Wilcoxon two-sample test was not significant, indicating that Thinking Maps® did not influence the variation in CRCT scores. There is not sufficient evidence to reject the claim that the CRCT-ranked mean scores for the non-usage and usage groups had equal-ranked mean scores (see Tables 12 and 13). The distribution of CRCT-ranked sum scores in the box plot graphically does not depict large differences in the lower quartile, middle quartile, and upper quartile scores based on non-usage and usage levels. The box plot reveals the same where the

distribution for non-usage and usage are similar (see Figure 9). The bar chart shows that there is approximately equal distribution of the median CRCT scores above and below the median for both non-usage and usage groups (see Figure 10).

Table 11

Wilcoxon Test Results by Non-Usage and Usage, 2012-2013

Wilcoxon Scores (Rank Sums) for Variable CRCT Classified by Variable Use					
Use	N	Sum of Scores	Expected Under H_0	SD Under H_0	Mean Score
1	349	125,994.50	122,673.50	2,686.03433	361.016759
2	353	120,758.50	124,079.50	2,686.03433	342.092068
Average scores were used for ties.					

Note: SD = Standard Deviation; H_0 = Null Hypothesis

Table 12

Wilcoxon Two-Sample Test Results, 2012-2013

Statistic	125994.50
Normal Approximation	
z	1.2362
One-Sided Pr > z	0.1082
Two-Sided Pr > |z|	0.2164
t Approximation	
One-Sided Pr > z	0.1084
Two-Sided Pr > |z|	0.2168
z includes a continuity correction of 0.5	

Table 13

Kruskal-Wallis Two-Sample Test Results for Non-Usage and Usage, 2012-2013

Kruskal-Wallis Test	
Chi-Square	1.5287
DF	1
Pr > Chi-Square	0.2163

Figure 9

Wilcoxon Box Plot Scores for CRCT by Non-Usage and Usage, 2012-2013

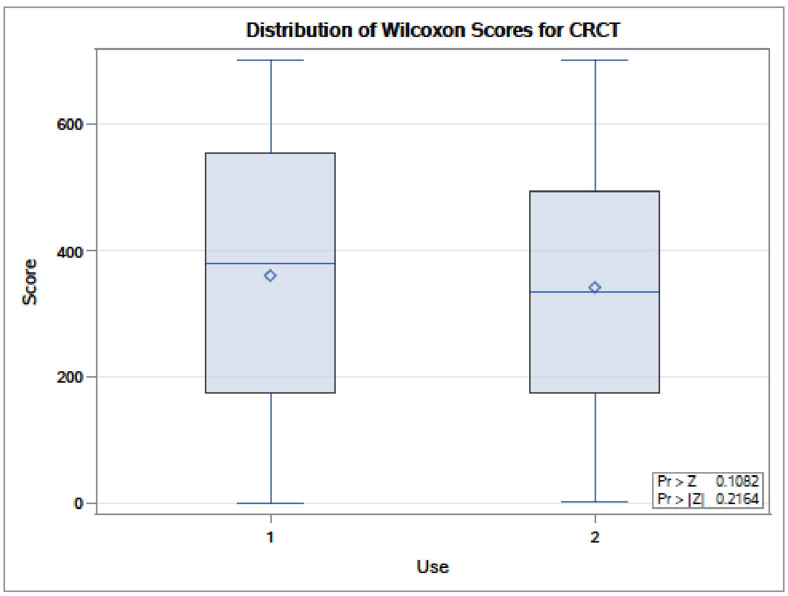
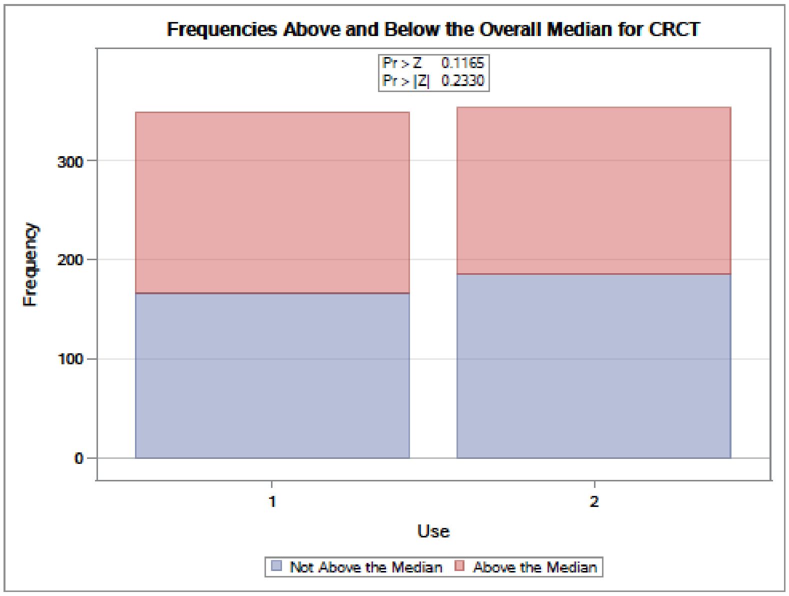


Figure 10

Frequencies Above & Below the Median CRCT Scores by Non-Usage and Usage, 2012-2013



The asymptotic *p*-value for the Kolmogorov-Smirnov test is 0.07, which indicates a failure to reject the null hypothesis and that the CRCT score distributions are identical for the non-usage and usage groups (see Tables 14 and 15). The empirical distribution of CRCT scores shows the proportion of scores fall in the CRCT score ranges by non-usage, shown by the blue curve, and usage, shown by the red curve. The graph shows that the variation in distribution of CRCT scores across the non-usage and usage levels. Both curves for the non-usage and usage groups are closely aligned and follow similar trends with regard to the CRCT scores, and reiterating the fact that the non-usage or usage of Thinking Maps® is not able to explain sufficient variation in the CRCT scores to a statistically significant degree (see Figure 11).

Table 14

Kolmogorov-Smirnov Asymptotic Results, 2012-2013

KS	0.048868	D	0.097738
KSa	1.294774	Pr > KSa	0.07

Table 15

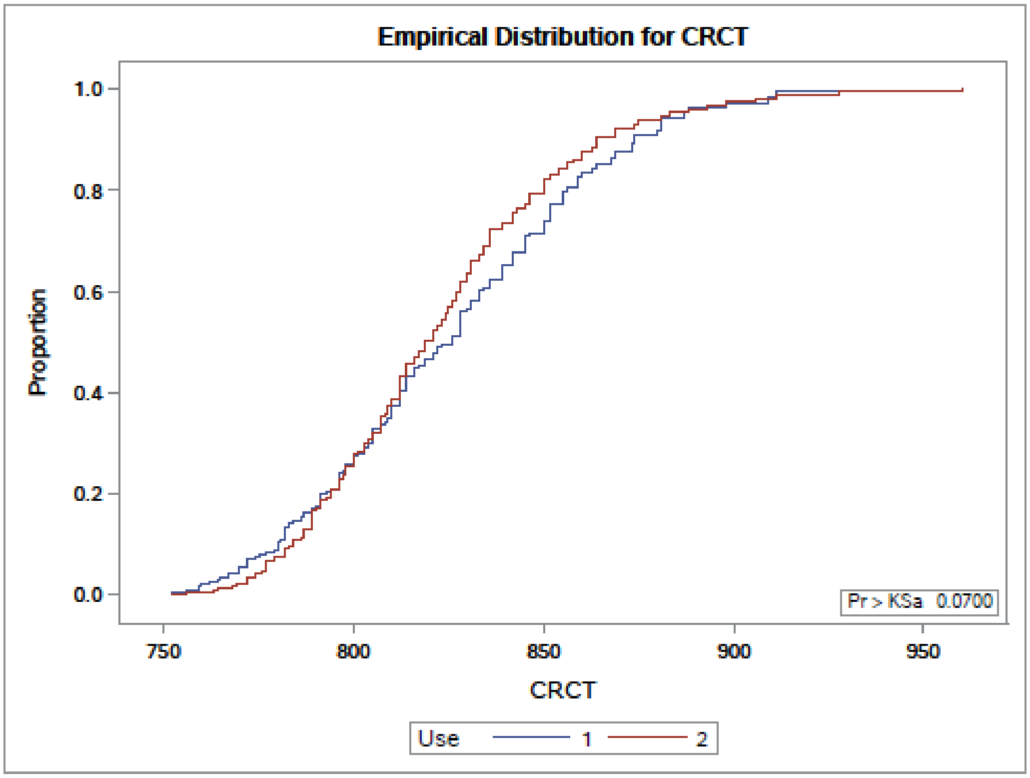
Kolmogorov-Smirnov Empirical Distribution Test by Non-Usage and Usage, 2012-2013

Kolmogorov-Smirnov Test for Variable CRCT Classified by Variable Use			
Grade	N	EDF at Maximum	Deviation from Mean at Maximum
1	349	0.624642	-0.918148
2	353	0.72238	0.912931
Total	702	0.673789	
Maximum Deviation Occurred at Observation 72			
Value of CRCT at Maximum = 836.00			

Note. EDF = Empirical Distribution Function

Figure 11

Empirical Distribution Graph for CRCT Scores by Non-Usage and Usage, 2012-2013



Friedman's non-parametric ANOVA, which belongs to the PROC GLM library function in SAS, was used to determine the simultaneous influence of the sixth, seventh, and eighth grades and Thinking Maps® non-usage or usage on CRCT science scores. The model was significant (F = 23.30, $p < .0001$) (see Table 16). Grade level and Thinking Maps® together explained 9.11% variance in the CRCT scores (see Table 17). The interaction plot between grade levels marked on the X-axis and the Thinking Maps®, marked as non-usage by the blue line and usage by the red line, shows that the CRCT scores were higher for students who utilized Thinking Maps®. The seventh grade students had the highest CRCT scores for both the non-usage and usage groups (see Figure 12). It is difficult to determine whether the interaction

between the grade levels and Thinking Maps® is statistically significant because the CRCT scores follow a non-normal distribution and the scores that were sampled from the entire population of CRCT scores do not originate from the same distribution.

Table 16

Friedman's Two-Way ANOVA Results, 2012-2013

Friedman's Two-Way Non-Parametric ANOVA
The GLM Procedure
Dependent Variable: CRCT

Source	DF	Sum of Scores	Mean Square	F Value	Pr > F
Model	3	76091.8734	25363.9578	23.30	< .0001
Error	697	758701.4190	1088.5243		
Corrected Total	700	834793.2924			

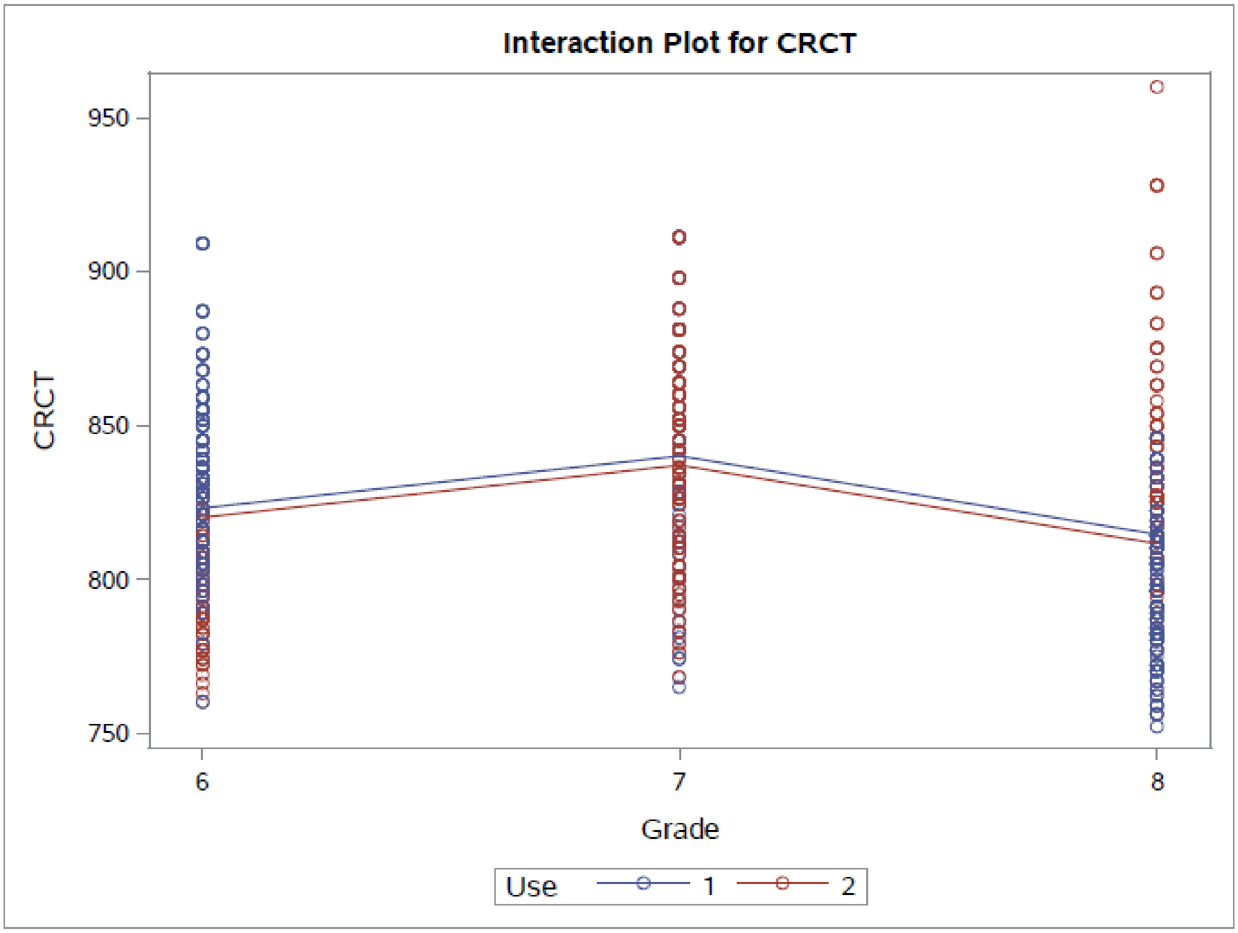
Table 17

R-Square Results, 2012-2013

R-Square	Coeff Var	Root MSE	CRCT Mean
0.091151	4.002739	32.99279	824.2553

Figure 12

Interaction Plot for CRCT Scores by Grade Level by Non-Usage and Usage, 2012-2013



Descriptive Statistics, 2013-2014

Sixth, seventh, and eighth grade students from a Title I middle school located in a suburban school district in middle Georgia provided the sample and focus of this study. Scores for 702 and 374 students for the 2012-2013 and 2013-2014 school years, respectively, were separated into two groups: (a) Students who did not use Thinking Maps® instruction in the classroom and (b) Students who did use Thinking Maps® instruction in the classroom. Appropriate statistical tests were conducted.

Table 18 provides information on descriptive statistics of CRCT scores based on usage or non-usage of Thinking Maps®. The 2013-2014 group data showed a total of 374 students, of which 182, or 48.67% of the total, were in the Non-Thinking Maps® or non-usage instructional group, and the Thinking Maps® or usage instructional group included 192 students, or 51.34% of the total number of tested students. In the non-usage group, the mean CRCT score was 820.90 (n=182, SD=35.107), and the mean CRCT score for the usage group was 845.25 (m=192, SD=33.357) (see Table 18). The difference in means was 24.35, and the difference in standard deviations was 1.75.

There were 72 sixth grade students comprising 51.06% of the population, who were in the Non-Thinking Maps® or non-usage instructional group, and 69 sixth grade students, or 48.94%, who were in the Thinking Maps® or usage instructional group, for a total of 141 sixth grade students comprising 37.59% of the total population. The seventh grade comprised of 49 students in the Non-Thinking Maps® or non-usage instructional group, or 46.67% of the population, and 56 students in the Thinking Maps® or usage instructional group, or 53.33% of the total number of students, totaling 105 students who were 28.07% of the total number of tested students. The eighth grade group numbered 61 in the Non-Thinking Maps® or non-usage instructional group, or 47.66%, and 67 in the Thinking Maps® or usage instructional group, or 52.34% of the total number of eighth graders. This group comprised 34.22% of the total population of students taking the 2013-2014 science CRCT, or 128 students (see Table 19).

Table 19 presents descriptive statistics of the CRCT science test scores by grade level. For the 2013-2014 CRCT science test administration, there was a total of 141 sixth grade students, comprising 37.59% of the population tested. The mean CRCT score for the sixth grade was 820.79 (m=141, SD=31.345). There was a total of 105 seventh grade students, making up

28.07% of the population tested. The mean CRCT score for the seventh grade was 852.86 (n=105, SD=39.038). There was a total of 128 eighth grade students, making up 34.22% of the population tested. The mean CRCT score for the eighth grade was 831.33 (n=128, SD=32.271). The difference between the means measured 32.07 between the sixth and seventh grades and 21.53 between the seventh and eighth grades. The average difference between the means was 26.80 (see Table 19).

The confidence interval is defined as a range of the population that would occur in 95% of the cases on multiple occasions (NIST, 2013). The sixth grade results show a mean of 813.76 (n=72, SD=34.486) for the non-usage group, and a mean of 828.12 (n=69, SD=25.966) for the usage group, the usage group showing a 14.36 point difference. The difference between the upper bound and lower bound scores in the 95% confidence interval for the sixth grade was 16.21 for the non-usage group and 12.47 for the usage group, a difference of 3.74. The seventh grade non-usage group scored a mean of 850.04 (n=49, SD=34.40), and the usage group had a mean of 855.32 (n=56, SD=42.846). The mean scores for the non-usage and usage groups were closer in the seventh grade, but the non-usage group still scored higher than the usage group. The difference in the seventh grade confidence intervals was 19.76 for the non-usage group and 22.95 for the usage group, a difference of 3.19. The non-usage group in the eighth grade scored a mean of 805.90 (n=61, SD=19.514), and the usage group scored a mean of 854.48 (n=67, SD=22.721). Contrary to the other two grades, the eighth graders who used Thinking Maps® scored an average of 48.58 points higher than the non-usage group. The difference in the eighth grade confidence intervals was 1.00 for the non-usage group and 11.08 for the usage group, a difference of 10.08. The mean CRCT scores for all of the Thinking Maps® non-usage groups scored lower than their usage counterparts (see Table 19).

Table 18

Descriptive Statistics, 2013-2014 Science CRCT

	N	Mean	SD	SE Mean	Skewness	SE	Kurtosis	SE
Non-Usage	182	820.90	35.107	2.602	0.345	.180	-0.494	.358
Usage	192	845.25	33.357	2.407	0.734	.175	1.067	.349

Note. N = sample size; SD = standard deviation; SE = standard error

Table 19

Statistics Non-Usage and Usage by Grade, 2013-2014

	6th Grade			7th Grade			8th Grade		
	Non-Usage	Usage	Total	Non-Usage	Usage	Total	Non-Usage	Usage	Total
N	72	69	141	49	56	105	61	67	128
% Total Tested	51.06	48.94	37.59	46.67	53.33	28.07	47.66	52.34	34.22
Mean	813.76	828.12	820.79	850.04	855.32	852.86	805.90	854.48	831.33
SD	34.486	25.966	31.345	34.40	42.846	39.038	19.514	22.721	32.271
SE	4.064	3.126	2.64	4.914	5.725	3.81	2.498	2.776	2.852
Skewness	0.288	0.135		-0.607	0.672		-0.269	1.054	
SE	0.283	0.289		0.34	0.319		0.306	0.293	
Kurtosis	-0.53	-0.208		-0.218	-0.153		0.348	0.62	
SE	0.559	0.57		0.668	0.628		0.604	0.578	
95% CI									
Upper Bound	821.87	834.35		859.92	866.80		801.90	860.02	
Lower Bound	805.66	821.88		840.16	843.85		800.90	848.94	
Non-Usage Total	182								
Usage Total	192								

Note. N = sample size; SD = standard deviation; SE = standard error; CI = confidence interval

Tests of Normality, 2013-2014

The histogram for the non-usage group showed a positive or right-skewed non-normal distribution with a skewness of .345 (SE = .180), while the histogram for the usage group showed a negative or left-skewed non-normal distribution with a skewness of .734 (SE = .175), a difference of .389 (see Figures 13 and 14). Westfall (2014) stated kurtosis "measures the departure from normality." The kurtosis value of the non-usage group was -.494 (SE = .358), which had negative kurtosis and was platykurtic. This indicated the non-usage group varied from normal distribution. The kurtosis value of the usage group was 1.067 (SE = .349), which is said to have positive kurtosis, and was also platykurtic. This indicated the usage group varied from a normal distribution (see Table 20). Normality was not supported by the Shapiro-Wilk test for each of the two groups, non-usage and usage, because all *p*'s < .05 (see Table 20). Levene's test for homogeneity of variances was used to determine that variances in the data set were equal when the data exhibited a non-normal distribution. Tests for homogeneity of variances showed $F(1,372) = 1.990$, $p = .159$, which was not statistically significant because $p > .05$, indicating there are equal variances in the non-usage versus usage of Thinking Maps® in the sample population (see Table 21).

Table 20

Tests of Normality for Non-Usage and Usage, 2013-2014

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Non-Usage	0.093	182	0.001	0.975	182	0.002
Usage	0.110	192	0.000	0.966	192	0.000

a. Lilliefors Significance Correction

Table 21

Levene's Test for Homogeneity of Variance, Non-Usage and Usage, 2013-2014

		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	1.990	1	372	0.159
	Based on Median	1.507	1	372	0.220
	Based on Median and with adjusted df	1.507	1	372.000	0.220
	Based on trimmed mean	2.057	1	372	0.152

Figure 13

Histogram of Science CRCT Scores, Non-Usage, 2013-2014

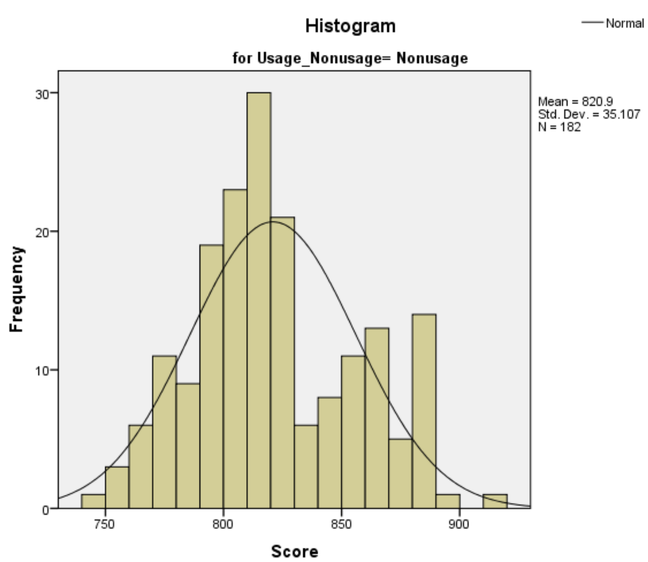
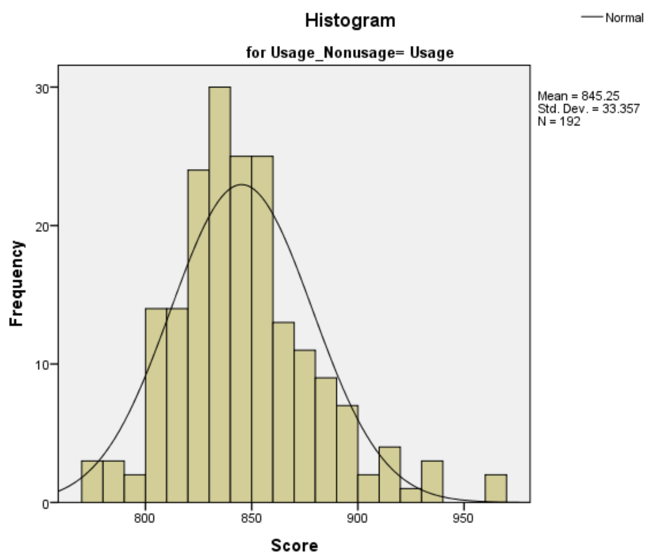


Figure 14

Histogram of Science CRCT Scores, Usage, 2013-2014



The histogram for the sixth grade reported a mean of 820.79 (n=141, SD=31.345) and showed a skewness of .048 with a standard error of .204, and a kurtosis of -.402 with a standard error of .406 (see Figure 15). The histogram for the seventh grade reported a mean of 852.86 (n=105, SD=39.038), and showed a skewness of .318 with a standard error of .236, and a kurtosis of .091 with a standard error of .467 (see Figure 16). The histogram for the eighth grade reported a mean of 831.33 (n=128, SD=32.271) and showed a skewness of .268 with a standard error of .214, and a kurtosis of .094 with a standard error of .425 (see Figure 17). All of them showed a non-normal distribution, and are all platykurtic. Normality was supported by the Shapiro-Wilk test for both sixth grade groups, and the two non-usage groups for the seventh and eighth grades because all p's > .05, but normality was not supported by the Shapiro-Wilk test for both usage groups for the seventh and eighth grades because both p's < .05 (see Table 22). Levene's test for homogeneity of variances was used to determine that variances in the data set were equal when the data exhibited a non-normal distribution. Tests for homogeneity of

variances showed $F(2,371) = 3.089$, $p = .047$, which was statistically significant because $p \leq .05$, indicating there is not a difference between the variances grade level versus non-usage/usage of Thinking Maps® within the population (see Table 23).

Figure 15

Histogram of Sixth Grade CRCT Scores, 2013-2014

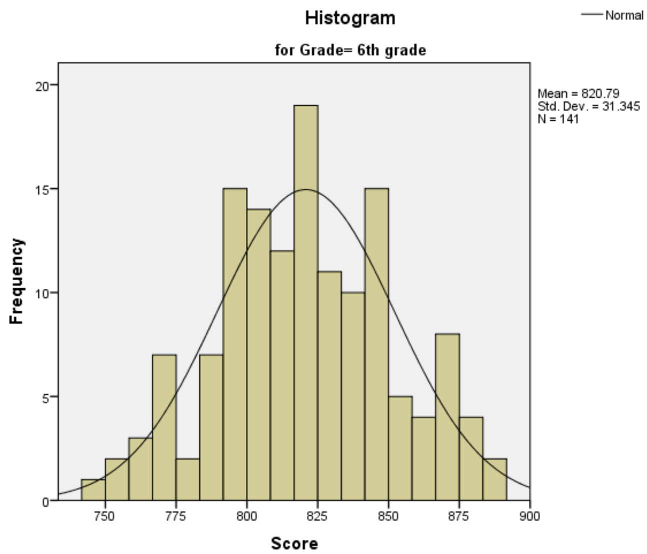


Figure 16

Histogram of Seventh Grade CRCT Scores, 2013-2014

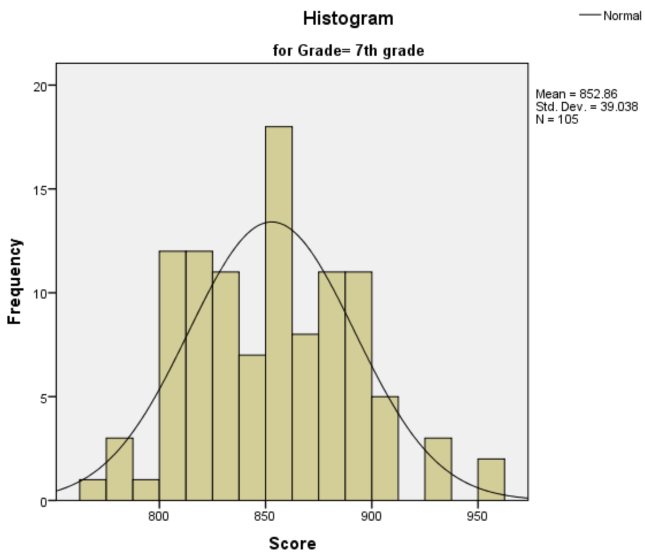


Figure 17

Histogram of Eighth Grade CRCT Scores, 2013-2014

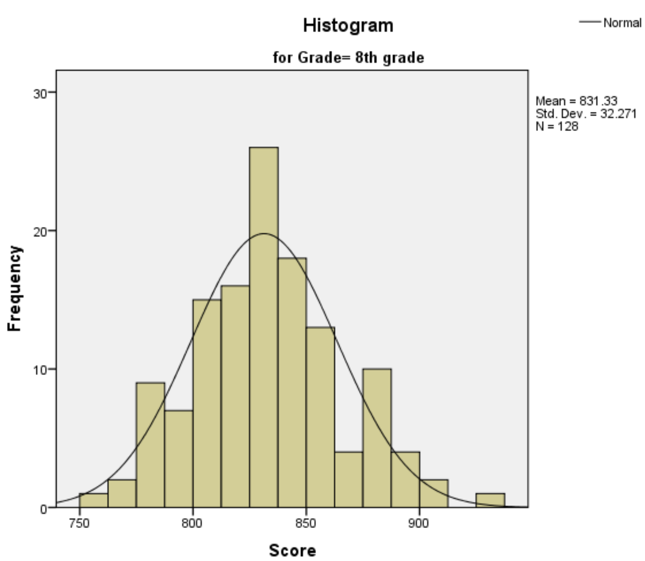


Table 22

Tests of Normality for Sixth, Seventh, and Eighth Grade CRCT Scores, 2013-2014

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Level	Non-Usage Usage	Statistic	df	Sig.	Statistic	df	Sig.
6	Non-Usage	.081	72	.200	.974	72	.146
	Usage	.066	69	.200	.990	69	.860
7	Non-Usage	.104	49	.200	.958	49	.076
	Usage	.099	56	.200	.950	56	.022
8	Non-Usage	.092	61	.200	.977	61	.310
	Usage	.175	67	.000	.898	67	.000

a. Lilliefors Significance Correction

Table 23

Levene's Test for Homogeneity of Variance, Grades 6, 7, and 8, 2013-2014

		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	3.089	2	371	0.047
	Based on Median	3.107	2	371	0.046
	Based on Median and with adjusted df	3.107	2	357.450	0.046
	Based on trimmed mean	3.107	2	371	0.046

Table 24

Tukey & LSD Post hoc Comparisons by Grade Level, 2013-2014

95% CI

		Mean Difference	SE	Sig.	Lower	Upper
6	7	-32.07	4.38	0.000	-42.38	-21.76
	8	-10.541	4.148	0.031	-20.30	-0.78
7	6	32.07	4.38	0.000	21.76	42.38
	8	21.529	4.474	0.000	11.00	32.06
8	6	10.541	4.148	0.031	0.78	20.30
	7	-21.529	4.474	0.000	-32.06	-11.00
6	7	-32.07	4.38	0.000	-40.68	-23.46
	8	-10.541	4.148	0.011	-18.70	-2.38
7	6	32.07	4.38	0.000	23.46	40.68
	8	21.259	4.474	0.000	12.73	30.33
8	6	10.541	4.148	0.011	2.38	18.70
	7	-21.529	4.474	0.000	-30.33	-12.73

Note. CI = Confidence Interval;

Transformations, 2013-2014

The Shapiro-Wilk and Kolmogorov-Smirnov normality tests indicated the scores for the three grade levels were significant for both groups, so there was no need to transform the scores to reach a normal distribution (see Table 22). Levene's test for homogeneity of variance showed $F(2, 371) = 3.089$, $p = .047$, which was statistically significant because $p < .05$ (see Table 23). The p value, while less than .05, would round to .05, so it was reaching normal distribution and variances between the grade levels. Post hoc comparisons using the Tukey HSD test indicated that there was a statistical difference between the eighth and sixth grade scores and the eighth and seventh grade scores, but there was very little difference between the seventh and eighth grade means (see Table 24). The LSD test confirmed the significance of the scores on the Tukey HSD test (all p's < .05) (see Table 24). The grade level had a statistically significant effect on

the achievement scores because $\eta^2 = 0.126$. This small effect size showed that 12.60% of the variance in CRCT scores is attributed to grade level.

The non-usage and usage groups did not follow a normal distribution and it was necessary to perform a log transformation and complete a Mann-Whitney test to determine the extent of the differences in variance.

Non-Parametric Analysis, 2013-2014

All non-parametric statistical analyses were conducted in SAS. The PROC NPAR1WAY is a procedure in the SAS library that is built-in to perform non-parametric analyses. The CRCT science scores followed a normal distribution. The ANOVA for each of the grade levels of sixth, seventh, and eighth grades showed a mean score of 820.79, 852.86, and 831.33, respectively (see Table 25). The model was significant ($F = 27.1691$, $p < .0001$), indicating that grade level has an effect on the CRCT scores (see Table 26). The box plot depicts the seventh grade as having higher mean scores than the sixth and eighth grades (see Figure 18).

Table 25

ANOVA Results for CRCT Scores by Grade Level, 2013-2014

Analysis of Variance for Variable CRCT

Classified by Variable Grade

Grade	N	Mean
8	141	820.787234
7	105	852.857143
6	128	831.328125

Table 26

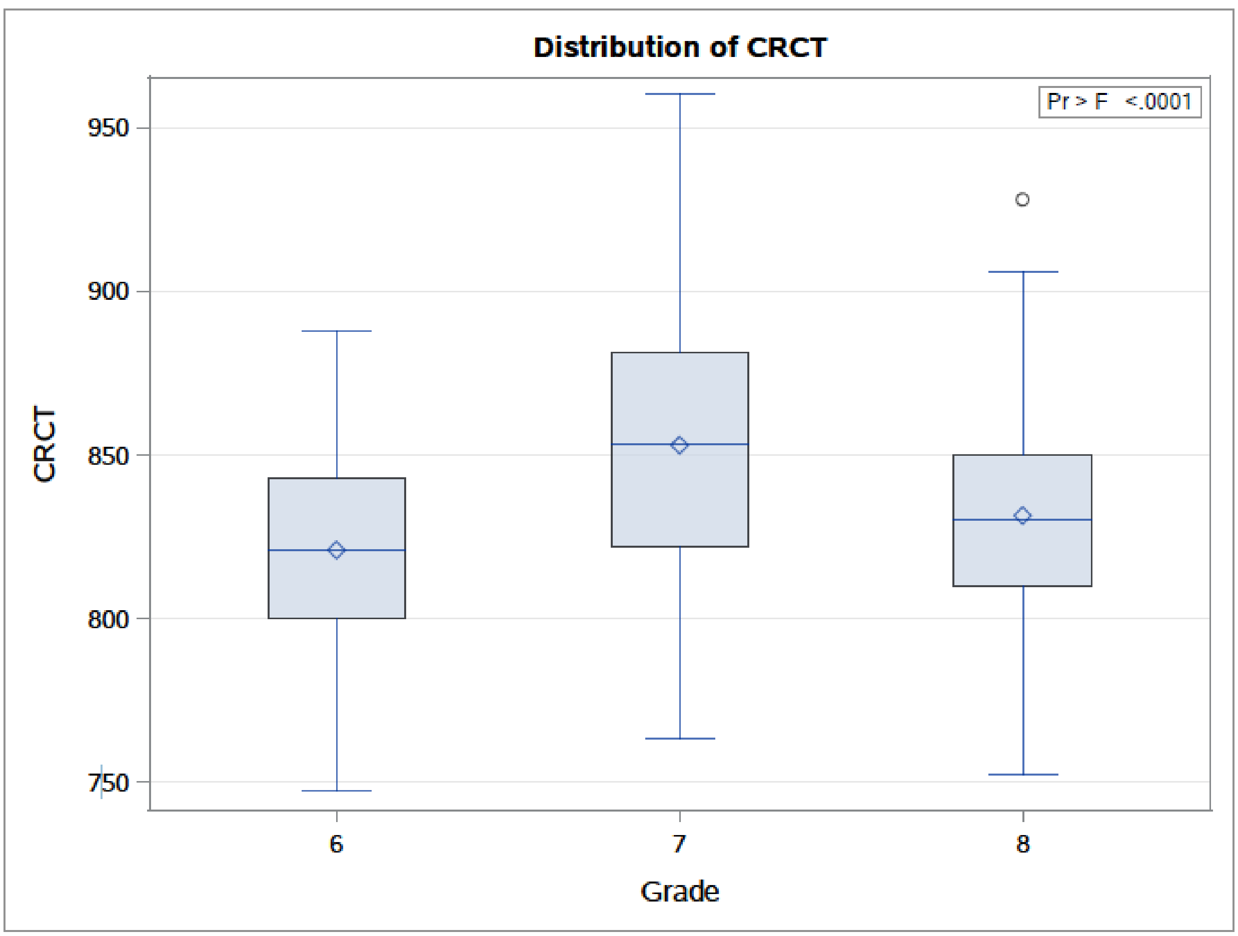
ANOVA Results F-Statistic for Grade Level, 2013-2014

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	2	62,730.94612	31,365.47306	27.1691	<.0001
Within	371	428,302.6929	1,154.4547		

Average scores were used for ties.

Figure 18

Distribution of CRCT Scores by Grade Level, 2013-2014



The Kruskal-Wallis test was significant ($\chi 2 = 42.7762$, $p < .01$) (see Table 27). Grade level had an effect on the CRCT scores to a statistically significant degree. There is enough evidence to reject the claim that CRCT-ranked mean scores from the three grade levels have equally ranked mean scores. The Wilcoxon rank sum test also shows the same picture as the Kruskal-Wallis test where not only the sum of scores was above the standard deviation of H_0, but also ranked mean score is different across grade levels with seventh grade having the highest CRCT-ranked mean score of 241.69. The CRCT mean scores, as well as the ranked mean scores are influenced most by the seventh grade, followed by the eighth grade and then the sixth grade (see Table 28). The distribution of CRCT-ranked sum scores in the box plot graphically shows differences in the quartile scores based on grade levels (see Figure 19). The median scores above the mean showed the seventh grade had the highest number of scores above the median, with a mean of .705, followed by the eighth grade with .50 and then the sixth grade with .34 (see Table 29). The median one-way analysis was significant ($\chi^2 = 31.2131$, $p < .01$) (see Table 30). While the frequency graph shows a greater frequency in the sixth and eighth grade scores, there were a larger number of scores that were above the median for the seventh grade than for the other two, followed by the eighth grade and then the sixth grade (see Figure 20).

Table 27

Kruskal-Wallis Chi-Square Results by Grade Level, 2013-2014

Chi-Square	42.7762
DF	2
Pr > Chi-Square	<.0001

Table 28

Wilcoxon Test Results by Grade Level, 2013-2014

Wilcoxon Scores (Rank Sums) for Variable CRCT

Classified by Variable Grade

Grade	N	Sum of Scores	Expected Under H_0	Std Dev Under H_0	Mean Score
8	141	21,272.00	26,437.50	1,013.01999	150.865248
7	105	25,377.50	19,687.50	939.29344	241.690476
6	128	23,475.50	24,000.00	991.75189	183.402344

Average scores were used for ties.

Figure 19

Distribution of Wilcoxon Scores by Grade Level, 2013-2014

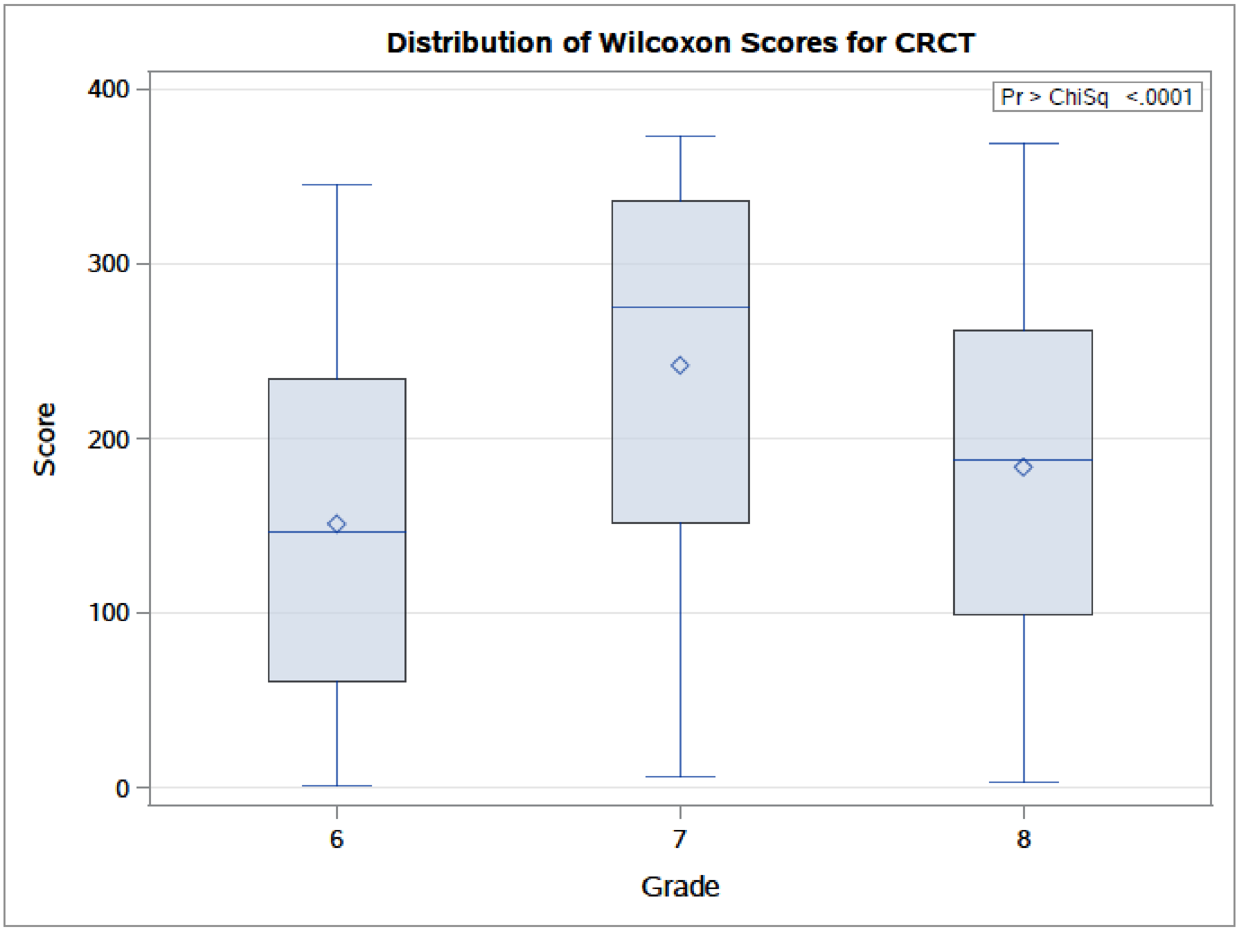


Table 29

Median Scores for CRCT Scores by Grade Level, 2013-2014

Median Scores (Number of Points Above Median) for Variable CRCT

Classified by Variable Grade

Grade	N	Sum of Scores	Expected Under H_0	Std Dev Under H_0	Mean Score
8	141	49.00	70.50	4.64927	0.347518
7	105	74.00	52.50	4.31090	0.704762

6	128	64.00	64.00	4.55166	0.500000

Average scores were used for ties.

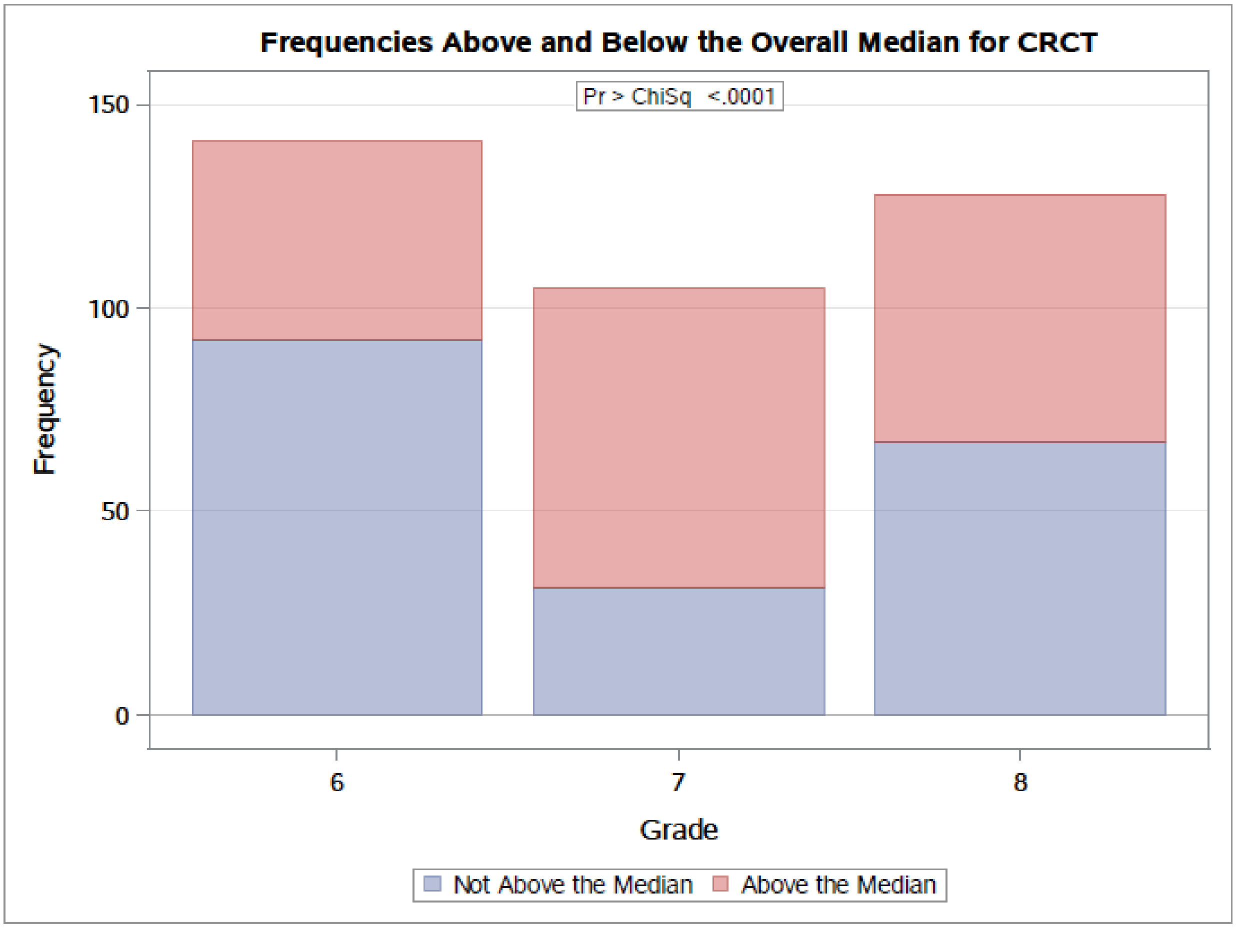
Table 30

Median One-Way Analysis Chi-Square Results, 2013-2014

Median One-Way Analysis	
Chi-Square	31.2131
DF	2
Pr > Chi-Square	0.0001

Figure 20

Frequency Graph for CRCT Scores Above and Below the Overall Median, 2013-2014



The asymptotic *p*-value for the Kolmogorov-Smirnov test is 2.909181, which indicates a rejection of the null hypothesis that CRCT score distributions are identical for the three grade levels, and the lowest empirical deviation from the mean at 0.309417 (see Tables 31 and 32). The empirical distribution of CRCT scores shows the proportion of scores falling within the CRCT score ranges. The graph shows that the variation in the distribution of CRCT scores is different across the three grade levels, but the magnitude of difference is more in the seventh grade scores when compared to the sixth and eighth grades. The proportion of CRCT scores

falling within a range is marked on the Y-axis, and the CRCT score ranges are marked on the X-axis. The graph shows more variation in the seventh grade curve of the CRCT score distribution, especially after the 825 mark, as indicated by a steeper curve when compared to the sixth and eighth grade curves (see Figure 21).

Table 31

Kolmogorov-Smirnov Test Results by Grade Level, 2013-2014

Kolmogorov-Smirnov Test for Variable CRCT Classified by Variable Grade			
Grade	N	EDF at Maximum	Deviation from Mean at Maximum
6	141	0.773050	1.369060
7	105	0.419048	-2.446013
8	128	0.726563	0.778479
Total	374	0.657754	

Maximum Deviation Occurred at Observation 282
Value of CRCT at Maximum = 845.00

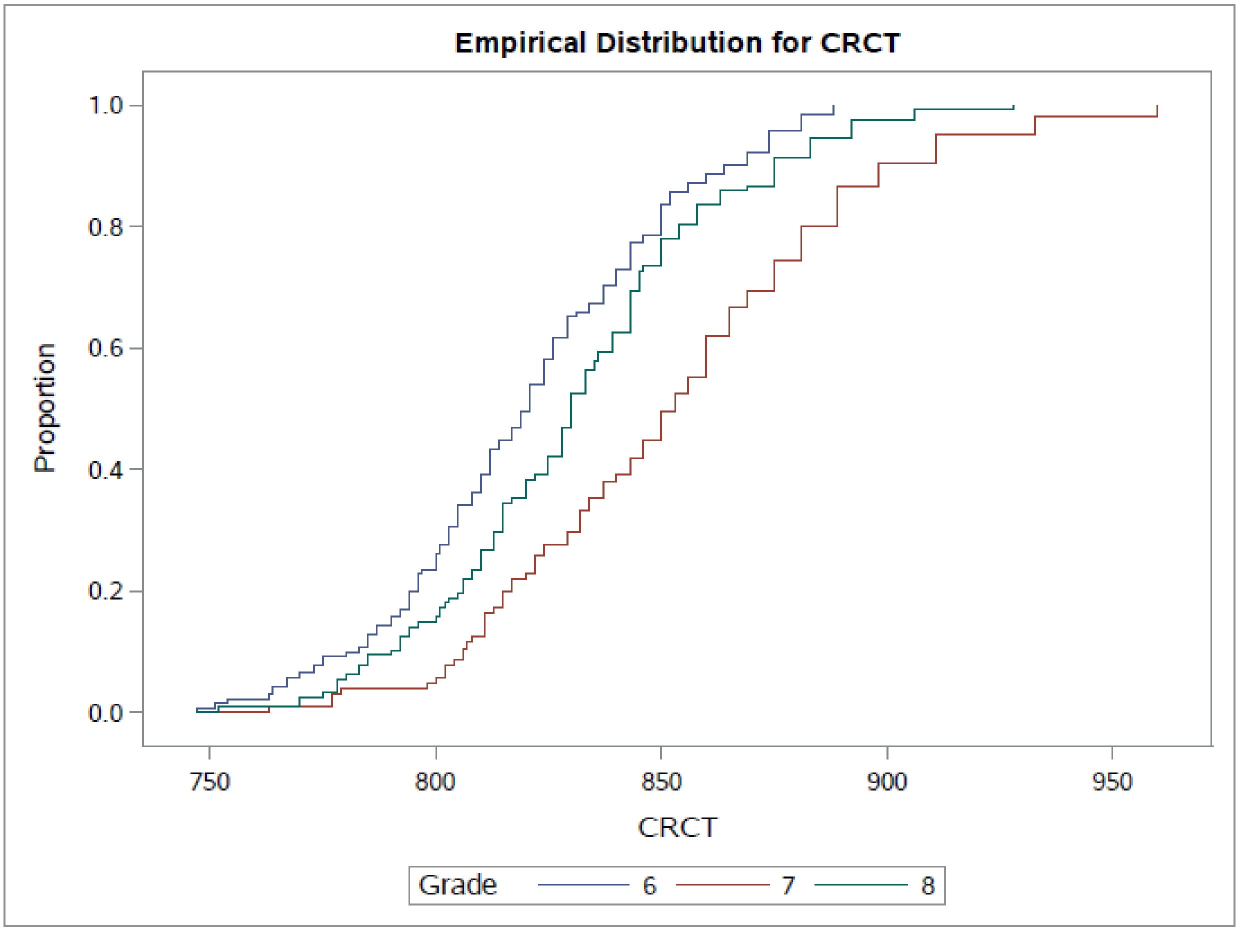
Table 32

Kolmogorov-Smirnov Asymptotic Results, 2013-2014

KS	0.150430	KSa	2.909181

Figure 21

Empirical Distribution for CRCT Science Scores, 2013-2014



The Wilcoxon two-sample test was used to determine if there was an influence of non-usage or usage of Thinking Maps® on the variation of CRCT science scores. The mean CRCT score for the non-usage and usage groups was 820.90 and 845.25, respectively. The Wilcoxon mean-ranked CRCT scores for non-usage (coded as 1) was 150.59, and for usage (coded as 2) was 223.66 (see Table 33).

The Wilcoxon two-sample test suggests there is a statistically significant difference, indicating that Thinking Maps® use does have an influence on the variation in CRCT scores (see

Tables 34 and 35). There is sufficient evidence to reject the claim that CRCT-ranked mean scores for the non-usage and usage groups have equal ranked-mean scores. The distribution of CRCT-ranked sum scores in the box plot graphically represents differences in the quartile scores based on non-usage and usage levels (see Figure 22). The box plot also reveals the same picture where the distribution for non-usage and usage are similar (see Figure 23). The bar graph depicts that there is an approximately equal distribution of median CRCT scores above and below the mean for both non-usage and usage groups, but there is a much larger number of scores above the mean for the usage group than for the non-usage group (see Figure 24).

Table 33

Wilcoxon Test Scores for Non-Usage and Usage, 2013-2014

Wilcoxon Scores (Rank Sums) for Variable CRCT Classified by Variable Use					
Use	N	Sum of Scores	Expected Under H_0	Std Dev Under H_0	Mean Score
1	183	27557.00	34404.00	1049.02449	150.584699
2	192	42943.00	36096.00	1049.02449	223.661458
Average scores were used for ties.					

Table 34

Wilcoxon Test Results, Non-Usage and Usage, 2013-2014

Wilcoxon Two-Sample Test	
Statistic	27557.00
Normal Approximation	

z	-6.5265
One-Sided Pr > z	< .001
Two-Sided Pr > |z|	< .001
t Approximation	
One-Sided Pr > z	< .001
Two-Sided Pr > |z|	< .001

z includes a continuity correction of 0.5

Table 35

Kruskal-Wallis Test Results, Non-Usage and Usage, 2013-2014

Chi-Square	42.6019
DF	1
Pr > Chi-Square	< .0001

Figure 22

Wilcoxon Test Results Box Plot, 2013-2014

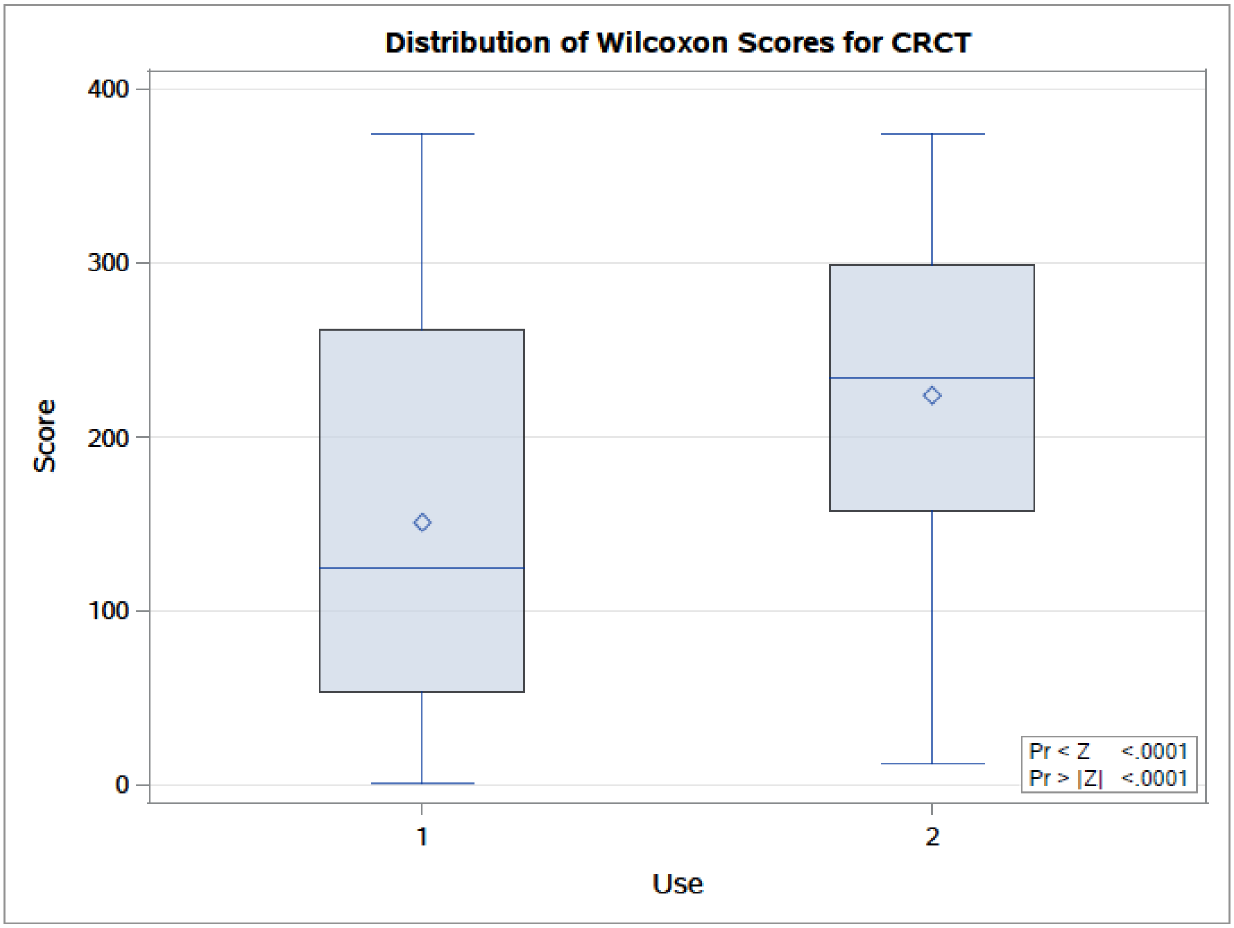


Figure 23

Frequency Graph for CRCT Scores Above and Below the Overall Median, 2013-2014

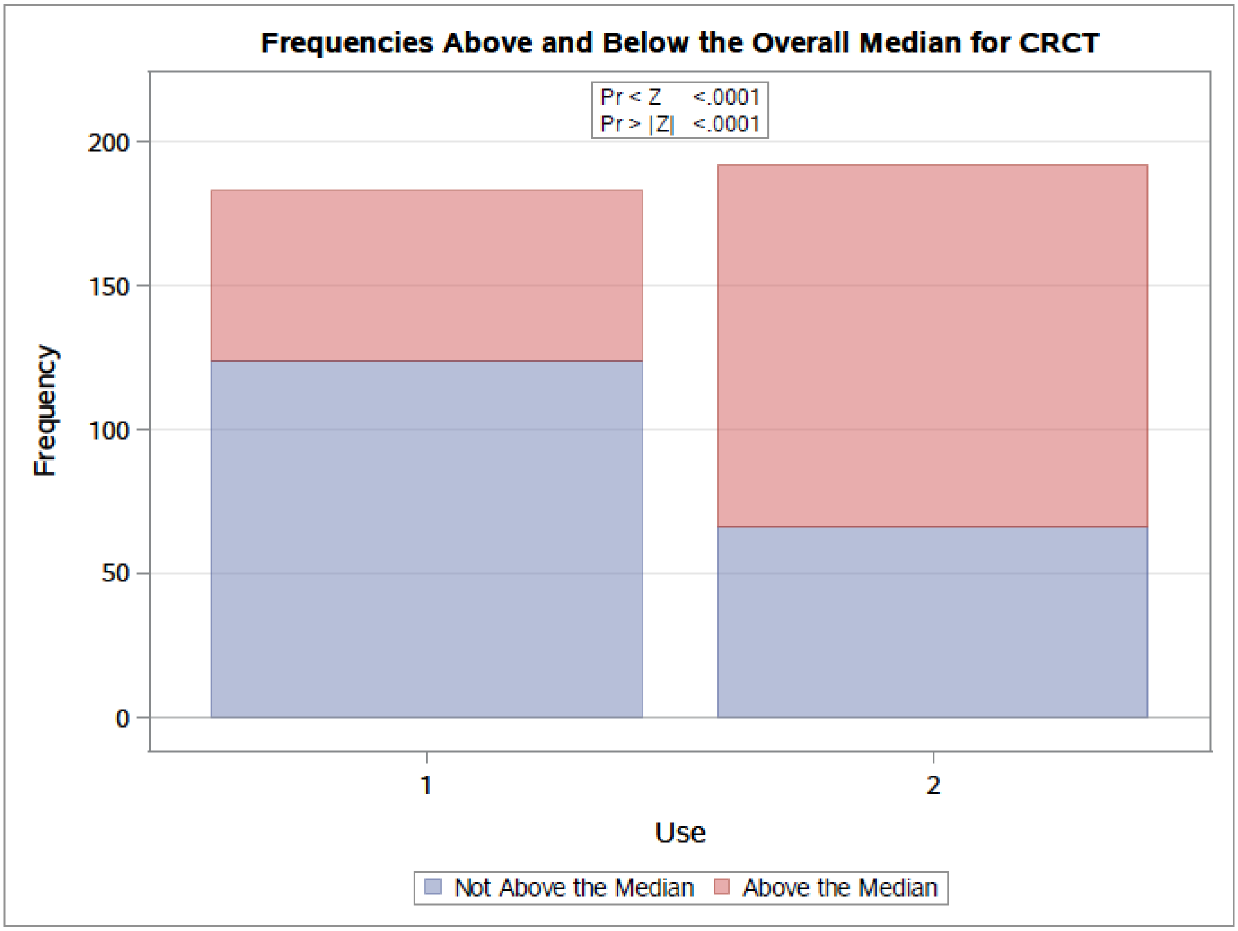
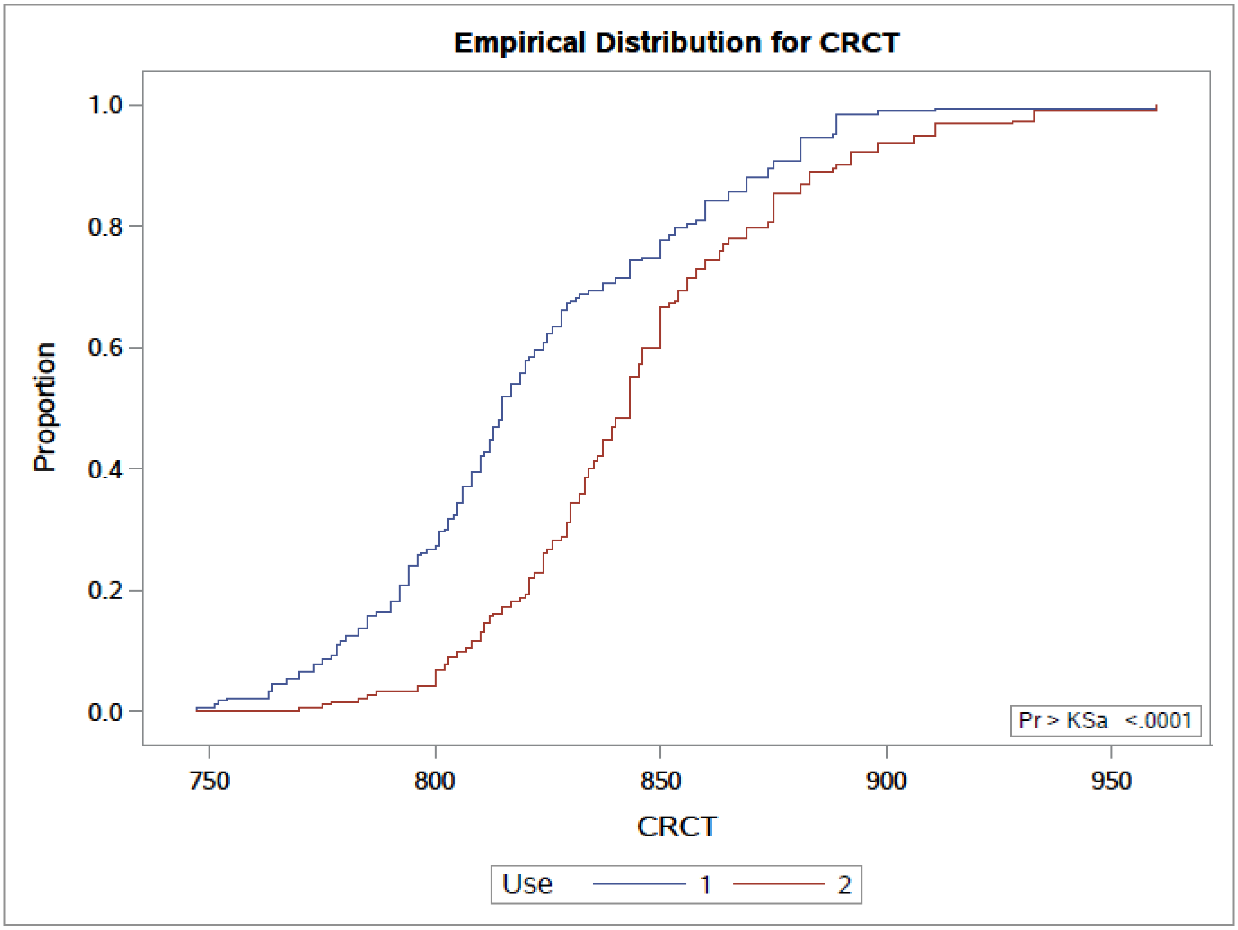


Figure 24

Empirical Distribution Graph for CRCT Scores, Non-Usage and Usage, 2013-2014



Friedman's non-parametric ANOVA, which belongs to the PROC GLM library function in SAS was used to determine the simultaneous influence of grade level (sixth, seventh, and eighth) and Thinking Maps® (non-usage and usage) on the CRCT scores. The model was significant because F = 37.44, $p < .0001$ (see Table 36). Grade level and Thinking Maps® together explained approximately 23.2% of the variance in the CRCT scores (see Table 37). The interaction plot between grade levels, marked on the X-axis, and Thinking Maps®, with non-

usage shown by the blue line and usage marked by the red line, shows that the CRCT scores were higher for students who utilized Thinking Maps® (see Figure 25). The seventh grade students had the highest CRCT scores for both non-usage and usage groups and this trend was prevalent across all grade levels. It is difficult to determine whether the interaction between grade levels and Thinking Maps® is statistically significant because the CRCT scores follow a non-normal distribution, and the scores that were sampled from the entire population of CRCT scores did not originate from the same distribution.

Table 36

Friedman's Two-Way Non-Parametric ANOVA Test Results, 2013-2014

Friedman's Two-Way Non-Parametric ANOVA

The GLM Procedure

Dependent Variable: CRCT

Source	DF	Sum of Scores	Mean Square	F Value	Pr > F
Model	3	114,358.4299	38,119.4766	37.44	< .0001
Error	370	376,675.2092	1,018.0411		
Corrected Total	373	491,033.6390			

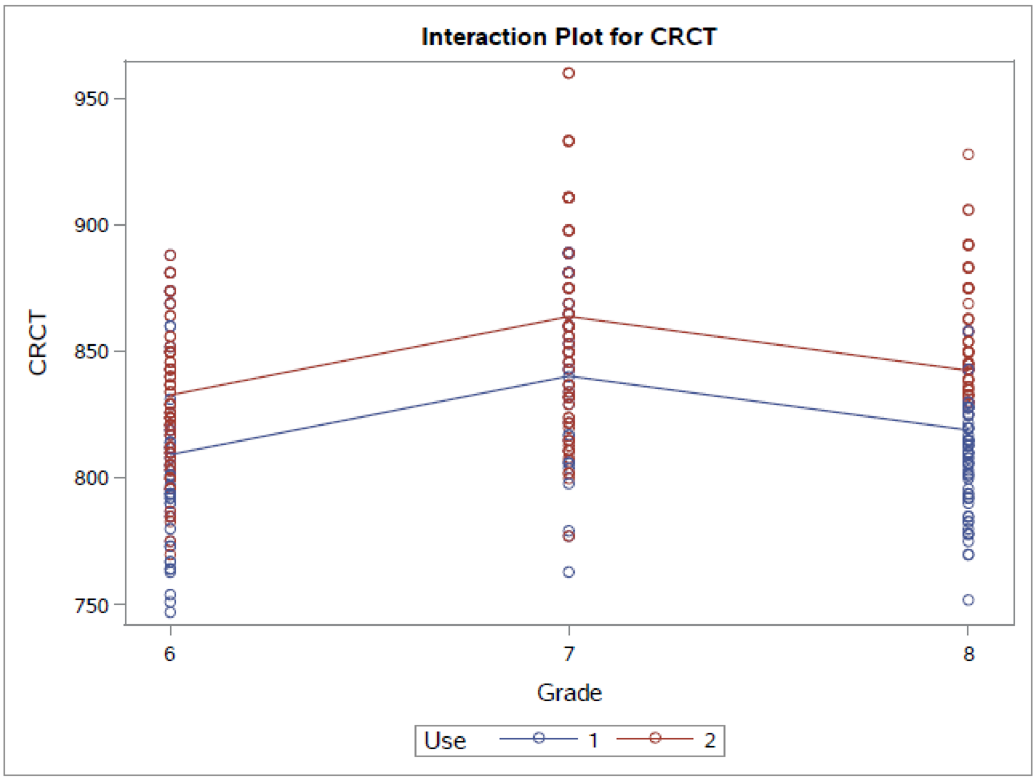
Table 37

R-Squared Results, 2013-2014

R-Square	Coeff Var	Root MSE	CRCT Mean
0.232893	3.828512	31.90676	833.3984

Figure 25

Interaction Plot for CRCT Scores by Grade Level for Non-Usage and Usage, 2013-2014



Research Questions

The purpose of this study was to determine if the use of Thinking Maps® had an effect on the achievement of middle grades students in the science classroom by an analysis of scores from the 2012-2013 and 2013-2014 administrations of the Georgia CRCT. In addition, science teachers' perceptions of the usage or non-usage of Thinking Maps® was investigated to

determine if a relationship existed between the teachers' perceptions and the implementation of Thinking Maps® in middle grades science.

Research Question 1: To what extent do Thinking Maps® affect middle grades students' academic achievement in science?

Research Question 2: What are teachers' perceptions about the use of Thinking Maps® with middle grades students?

Research Question 3: What, if any, is the relationship between the use of Thinking Maps® and teachers' perception and implementation in middle grades?

Data Analysis

All statistical tests such as the Kolmogorov-Smirnov, Kruskal-Wallis, Wilcoxon rank sum scores, and Friedman's analysis were performed using SPSS version 24, the Statistical Package for the Social Sciences®, published by IBM, and the SAS Institute's Statistics Analysis Software (SAS/STAT®) statistical analysis software packages. For this study, the non-usage or usage of Thinking Maps® in the science classroom served as the independent variables. The dependent variable was the student achievement in science for grades six through eight as measured on the 2012-2013 and 2013-2014 administrations of the Georgia Criterion-Referenced Competency Tests (CRCT).

The 2012-2013 CRCT administration showed a total of 702 students, with a mean of 826.20 and a standard deviation of 34.851. The Non-Thinking Maps® or non-usage instructional group had a total of 349 students in it. The mean science test score for the Non-Thinking Maps® or non-usage instructional group was 825.94, with a standard deviation of 36.50. The Thinking Maps® or usage instructional group included 353 students in it, who

scored a mean of 826.45, with a standard deviation of 33.202. In comparing the means of both groups, there was only a 0.51 difference.

Non-parametric statistical tests were conducted for the data following a non-normal distribution. The Kruskal-Wallis test was significant, showing that grade level had an effect on the CRCT scores to a statistically significant degree (see Table 8). The Wilcoxon-ranked sum scores test is a non-parametric form of the t-test, and ranked CRCT scores by each grade level. For the 2012-2013 data, the Wilcoxon test showed the seventh grade having the highest-ranked mean score of 437.16 (see Table 7). This was confirmed by the box plot and the frequency bar graph (see Figures 6 and 7). Additionally, the empirical distribution graph for CRCT scores by grade level shows that the seventh grade had an effect on CRCT scores, with a greater number of scores occurring above the 850 score (see Figure 8).

However, the Kruskal-Wallis test was not significant for non-usage and usage, indicating that usage of Thinking Maps® did not have an influence on the CRCT scores to a statistically significant degree (see Table 13). The Wilcoxon test was used to show the influence of non-usage and usage of Thinking Maps® on CRCT science scores. The Wilcoxon was not significant for the 2012-2013 data, meaning Thinking Maps® did not influence the variation in CRCT scores. Because the means were close, there was not sufficient evidence to reject the claim that non-usage and usage had an effect on scores, as shown in Table 11. This was shown on the box plot and bar graph as well (see Figures 9 and 10). Additionally, the empirical distribution graph for non-usage and usage showed the two curves as closely aligned (see Figure 11).

Friedman's non-parametric ANOVA was used to determine the influence of both grade level and amount of usage on the CRCT science scores. The model was significant, showing that

grade level and usage of Thinking Maps® together explained 9.11% of the variance in the CRCT scores (see Tables 16 and 17). Figure 17 shows the interaction between grade levels and non-usage or usage, and shows the CRCT scores for those students who used Thinking Maps® were higher. However, it is difficult to determine if the interaction between grade levels and Thinking Maps® were significant because the CRCT scores followed a non-normal distribution, and the CRCT scores did not originate from the same distribution.

The 2013-2014 CRCT administration showed a total of 374 students, with a mean of 833.075 and a standard deviation of 34.232. The Non-Thinking Maps® or non-usage group had a total of 182 students in it. The mean science test score for the Non-Thinking Maps® or non-usage group was 820.90, with a standard deviation of 35.107. The Thinking Maps® or usage instructional group included 192 students, who scored a mean of 845.25, with a standard deviation of 33.357. In comparing the means of both groups, there was a difference of 24.35.

Non-parametric statistical tests were conducted for the data following a non-normal distribution. The Kruskal-Wallis test was significant, showing that grade level had an influence on the CRCT scores to a statistically significant degree (see Table 27). The Wilcoxon rank sum test ranked the CRCT scores by grade level. For the 2013-2014 data, the Wilcoxon test showed that the seventh grade influenced the CRCT scores the most, followed by the eighth, and then the sixth grades (see Table 28). The box plot and frequency bar graph show a greater number of CRCT scores were above the mean for the seventh grade than in the sixth grade or eighth grade (see Figures 19 and 20). The empirical distribution graph for the three grade levels indicated a greater number of scores in the seventh grade as having a higher mean than the sixth and eighth grades, notably after the 825 score (see Figure 21).

The Kruskal-Wallis test for non-usage and usage was significant (see Table 35). It shows that usage of Thinking Maps® had an influence on the CRCT scores to a statistically significant degree. The Wilcoxon two-sample test was used to determine if there was an influence of non-usage or usage of Thinking Maps® on the CRCT science scores. It suggests there is a statistically significant difference, indicating that Thinking Maps® do have an influence on CRCT scores (see Tables 34 and 35). The box plot confirms that the distributions for non-usage and usage are similar (see Figure 22). The bar graph graphically depicts that there were a larger number of scores above the mean for the usage group than for the non-usage group (see Figure 23). The empirical distribution graph for non-usage and usage indicates a greater difference of means in the usage versus the non-usage group, especially between the 800-850 score range (see Figure 24).

Friedman's non-parametric ANOVA was used to determine if there was an influence between the three grade levels and Thinking Maps® non-usage or usage in terms of CRCT science scores. The test was significant (see Table 36). Grade level and usage together explained 23.2% of the variance in the CRCT scores (see Table 37). The interaction plot shows that the CRCT scores were higher for students who used Thinking Maps® in their science class (see Figure 25). The seventh grade had higher scores than the other two grade levels.

It is difficult to determine the interaction between grade levels and Thinking Maps® is statistically significant because of the non-normal distribution of the CRCT scores and the scores that were sampled from the population of CRCT scores did not originate from the same distribution. Because an interaction effect is difficult to interpret with non-normal data, to show a relationship, there must include a comparison of the means for each grade level with respect to the non-usage and usage as reported in the descriptive results (see Table 38).

Table 38

Comparison of Means by Grade and Usage, CRCT Science Scores

	Comparison of Means			
	2012-2013		2013-2014	
Grade Level	Non-Usage Mean	Usage Mean	Non-Usage Mean	Usage Mean
6	840.13	802.66	813.76	828.12
7	840.65	837.46	850.04	855.32
8	795.00	831.42	805.90	854.48

Teacher Perception Survey Results

Each science teacher and special education science co-teacher was asked to complete a Thinking Maps® Teacher Perception Survey developed by the researcher (see Appendix A). Thirteen surveys were completed and returned, six from regular education teachers and seven from the special education science co-teachers, one of which teaches gifted.

Demographic data analysis showed 61.54% of the respondents were above the age of 41, 84.62% who responded were female, 84.62% were white, 15.38% were black, and the mean amount of teaching experience was 16 years.

The selected school received initial training in Thinking Maps® during the 2008-2009 school year. Of the respondents, 11 of the 13 science teachers, or 84.62%, received the training during the first year of Thinking Maps® implementation. Of those who did not receive the training in the first year, one of the special education co-teachers received training in another state before moving to the selected school. The other teacher received informal training from a

member of the original team of educators from the selected school who was trained as a Thinking Maps® trainer for the school system.

The Teacher Perception Survey asked teachers if they believed Thinking Maps® help students learn science content. Of the respondents, 84.62%, or 11 of the 13, believe Thinking Maps® help students learn science content. While this does look like a high percentage, several teachers discussed either a reluctance to use Thinking Maps® or challenges inherent to using Thinking Maps®. For example, Teacher 7.1, who did not use Thinking Maps®, said, "I think it took things we already used and put a new name on it," and then indicated that they were "not effective." This does not mean this teacher did not use them as directed by the school system, however, and as indicated on the survey, the double bubble map, flow map, and tree map were the ones used most in this teacher's classes and the ones the teacher felt were most effective. Teacher 8.1, who did not feel Thinking Maps® were effective also indicated very little use Thinking Maps® in the classroom, felt that "Thinking Maps® forces [sic] students to process information in a way that may not be natural to them." This teacher went on to say, "I don't organize information that way so it's hard for me to see the opportunities to use them." Teacher 6.1 did not say if she felt they were effective, but she professed a reluctance to use them because, "They don't like or think they need the maps." Table 39 shows a comparison of mean CRCT scores for the teachers who did not utilize Thinking Maps® and those who utilized Thinking Maps® in their instructional practice.

Table 39

Comparison of CRCT Means by Teacher, Grade, and Non-Usage or Usage

Mean CRCT Score	Did Not Use Thinking Maps		Used Thinking Maps	
	2012-2013	2013-2014	2012-2013	2013-2014

	Teacher 1		Teacher 2	
6	840.13	813.76	802.66	828.12
7	840.65	850.04	837.46	855.32
8	795.00	805.90	831.42	854.48

Note: Teachers in narrative = 6.1(non-usage) & 6.2 (usage); 7.1 (non-usage) & 7.2 (usage); 8.1 (non-usage) & 8.2 (usage)

Teacher 8.2 discussed challenges when using Thinking Maps® in the classroom. "It was challenging, at times, to encourage students to expand their thinking [sic] to add more than just facts." One challenge teachers discussed across grade levels was how to incorporate different maps, and multiple maps, into their practice. Teacher 6.2 said, "The most challenging aspect has been trying to use more than the two that I use the most. Trying to use a variety of maps is difficult for me to incorporate." Teacher 7.2 said, "[The most challenging aspect is] finding one to use for every standard/element." The gifted science teacher wrote, "[The most challenging aspect is] using a variety of Thinking Maps®. Some maps lend themselves more easily to science concepts [sic] some maps are less useful than others." Besides these challenges, another challenge discussed was time. One special education co-teacher professed, "The most challenging aspect …is having the time during instruction for their use. There are so many standards that must be covered that students don't have adequate time to develop understanding or [sic] able to organize details on the Thinking Maps® before the curriculum/instruction moves forward." Another co-teacher agreed. "I can see the value in creating them, but unfortunately, we just don't have the time to take two or three days to develop them the way they probably should be."

The Teacher Perception Survey also asked about which three Thinking Maps® science teachers felt were most effective, which three they felt were least effective, and which three they

used the most. Teachers indicated they felt the tree map, flow map, and double bubble map were the most effective, in that order. Conversely, those maps the teachers felt least effective were the bubble map, circle map, and the bridge map, followed closely by the brace map. The Thinking Maps® used the most were the tree map, the flow map, and the double bubble map, followed by the brace map (see Table 40).

Lastly, the Teacher Perception Survey asked science teachers to indicate how often they used Thinking Maps® each week on average and each day with their classes. The science teachers' responses were that 53.85% used them once per week and 38% used them four to five times per day, an indication they used them with each of their content-area classes. This indicates usage in honors or accelerated classes as well as in interrelated or co-taught classes with a special education teacher.

Table 40

Data from Thinking Maps® Teacher Perception Survey

Thinking Map	Most Effective	Least Effective	Used Most	Primary Purpose
Brace	3	6	5	Whole-to-Part Relationship
Bridge	2	7	1	Analogy
Bubble	1	10	1	Describing using adjectives
Circle	0	7	0	Define in context; Brainstorming
Double Bubble	9	2	11	Comparison/Contrast
Flow	12	1	11	Sequence of Events
Multi-Flow	2	2	0	Cause/Effect Relationships
Tree	13	0	13	Classifying; Grouping

Summary

The results of the data analysis collected from the scores from the 2012-2013 and 2013-2014 administrations of the CRCT are presented in Chapter 4 with analyses. The CRCT scores were initially analyzed through SPSS, but because the scores followed a non-normal distribution, it was necessary to perform non-parametric tests using SAS. Tests were completed based on the three grade levels (sixth, seventh, and eighth), non-usage or usage of Thinking Maps® in instructional practice, and to determine interaction between the grade level and non-usage or usage.

The 2012-2013 Kruskal-Wallis test was statistically significant for the sixth, seventh, and eighth grades. The Wilcoxon rank sum test gave a similar picture as the Kruskal-Wallis, whereby the seventh grade influenced the most variance in the CRCT scores when compared to the sixth grade and eighth grade. The box plot showed the differences in the quartiles based on grade level. The frequency bar graph also showed that the seventh grade had a higher frequency of CRCT scores than the other two grade levels. The Kolmogorov-Smirnov asymptotic *p*-value indicated a rejection of the null hypothesis for the three grade levels. The empirical distribution graph showed that the magnitude of the distribution was greater for the seventh grade, especially after the 850 score.

The Kruskal-Wallis test for non-usage and usage of Thinking Maps® was not significant, and the Wilcoxon test for non-usage and usage was not significant, either. This indicated that Thinking Maps® usage did not influence the variation in CRCT scores. The box plot did not depict large differences based on non-usage or usage, and there was a similar distribution. The bar graph also showed an approximately equal distribution of the median CRCT scores above and below the median for both non-usage and usage groups.

Friedman's non-parametric ANOVA was used to determine the simultaneous influence of grade level and non-usage or usage of Thinking Maps® on CRCT scores. The Friedman's test was significant, together explaining that 9.11% of the variance in CRCT scores were influenced by grade level and usage of Thinking Maps®. The interaction plot showed that CRCT scores were higher for the students who used Thinking Maps®. The seventh grade has the highest scores.

The 2013-2014 ANOVA was significant for the sixth, seventh, and eighth grades, indicating that grade level had an effect on the CRCT scores. The box plot revealed that seventh grade had a higher mean score than the sixth or eighth grades.

The Kruskal-Wallis test was significant. Grade level had an effect on the CRCT scores to a statistically significant degree. The Wilcoxon test depicted a similar picture, with the seventh grade having the highest ranked mean score. The box plot showed differences in the quartiles based on the grade levels. The seventh grade also had the highest number of scores above the median, then eighth grade, followed by sixth grade. The frequency graph showed a greater frequency in the sixth and eighth grade scores, but the larger number of scores that were above the median were from the eighth grade, but the larger number of scores that were above the median were from the seventh grade. The Kolmogorov-Smirnov asymptotic *p*-value indicated a rejection of the null hypothesis for the three grade levels. The empirical distribution graph showed that a variation in the distribution of CRCT scores was different across the three grade levels, but the magnitude of the difference is more in the seventh grade scores than the sixth and eighth grades. The variation was shown by a steeper curve on the seventh grade curve when compared to the sixth and eighth grade curves.

The Kruskal-Wallis and Wilcoxon tests were both significant for non-usage versus usage, suggesting there is a statistically significant difference, that Thinking Maps® usage did have an influence on the variation in CRCT scores. There is sufficient evidence to reject the claim that ranked-mean scores for non-usage and usage have equal-ranked mean scores. The box plot shows differences in quartiles based on non-usage and usage. The bar graph showed an approximately equal distribution of median CRCT scores above or below the mean, but there were more scores above the mean for the usage group than for the non-usage group. The empirical distribution graph showed more scores between the 800-850 range for the usage group than for the non-usage group.

Friedman's ANOVA was used to determine the simultaneous influence of grade level and usage on the CRCT scores. The test was significant, explaining that 23.2% of the variance in the CRCT scores could be attributed to both grade level and usage of Thinking Maps®. The seventh graders had the highest scores in the usage group.

Most teachers (67%) who reported on the Teacher Perception Survey that they had a positive perception of and used Thinking Maps® regularly and consistently in their classes had a higher mean of scores in their classes than those who had a negative perception of or did not use Thinking Maps® regularly in their classes.

Based on the data results from the non-parametric testing and perceptions of teachers who felt favorably toward using Thinking Maps® regularly in their science classes, it can be concluded there is a trend in the favorable perception and consistent usage of Thinking Map® in the middle grades science classes and the increase in achievement score means of the students who use them regularly.

Because the interaction effect cannot be calculated due to the variance in the data sets to report a relationship, a comparison of the means for each grade level with respect to the non-usage and usage as reported in the descriptive results is found in Table 39.

CHAPTER 5

FINDINGS, DISCUSSION, CONCLUSIONS

The purpose of this study was to determine if there was a relationship between the achievement scores on the Georgia Criterion-Referenced Competency Test (CRCT) of students who used Thinking Maps® in their middle school science classes to learn content information as compared to students who did not use Thinking Maps®. The study focused on a statistical analysis of the scores for classes where Thinking Maps® were used and classes where Thinking Maps® were not used. Additionally, the perceptions of the science teachers in terms of the non-usage or usage of Thinking Maps® were analyzed. The final analysis was to determine if there was a relationship between the perceptions of the teachers and the non-usage or usage of the Thinking Maps® as related to achievement scores on the science assessments over two years. All participants in the study were in one middle Georgia Title I middle school having grades six, seven, and eight.

This chapter presents the research questions and the findings based on the review of literature, data analysis of the Georgia CRCT science scores for 2012-2013 and 2013-2014, and teacher perception surveys. Conclusions will be drawn based on the results of the data analysis and compared to the findings in the review of literature.

SUMMARY

The focus of the study was on achievement scores in middle grades science over two years. The dependent variable was the achievement score of 702 students on the Georgia CRCT in science over the 2012-2013 school year and 374 students over the 2013-2014 school year across the three grade levels (i.e., 6th, 7th, and 8th grades). The independent variables were the non-usage and usage of Thinking Maps® in the science classes across the three grade levels. The population consisted of 702 middle school students in the 2012-2013 school year, and 374 middle school students in the 2013-2014 school year. Science teachers, special education collaborative science teachers, and one gifted education collaborative science teacher were surveyed to ascertain their perception of Thinking Maps®, and if, when, how, and which maps they used in the instructional setting. The study focused on three research questions.

Research Question 1

To what extend do Thinking Maps® affect middle grades' student's academic achievement in science?

Non-parametric versions of statistical tests were performed in SPSS and SAS based on non-normal distributions using transformed data on both the 2012-2013 and 2013-2014 Georgia CRCT science scores. Tests were completed for the sixth, seventh, and eighth grade levels, the non-usage or usage of Thinking Maps®, and to determine interaction between the grade levels and amount of usage.

For the 2012-2013 data, Kruskal-Wallis, Wilcoxon, and Kolmogorov-Smirnov statistical tests showed that the greatest influence on CRCT science scores was in the seventh grade. The Kruskal-Wallis and Wilcoxon tests for non-usage versus usage of Thinking Maps® showed that usage of Thinking Maps® did not influence the variation in the CRCT scores. Friedman's non-

parametric ANOVA was performed to determine the simultaneous influence of grade level and non-usage or usage of Thinking Maps®, and showed that 9.11% of the variance was influenced by grade level and usage.

The 2013-2014 statistical tests indicated that grade level had an effect on the CRCT scores, and again, the greatest influence on CRCT science scores was in the seventh grade. The non-usage versus usage tests showed that usage of Thinking Maps® did have an influence on the variation of CRCT scores. Friedman's non-parametric ANOVA showed that 23.2% of the variance in the CRCT scores could be attributed to both grade level and usage of Thinking Maps®.

Research Question 2

What are teachers' perceptions about the use of Thinking Maps® with middle grades students?

Thirteen science and special education teachers responded to the Thinking Maps® Teacher Perception Survey developed by the researcher (see Appendix). Six were the regular education science teachers at the selected school, six were special education co-teachers, and one gifted education teacher.

Of the thirteen respondents, 84.62% said they believed Thinking Maps® help students learn science content. However, several teachers revealed they did not use them regularly because they either did not like using them or felt they were effective, or because of the challenges of incorporating them into existing curriculum. Challenges such as finding one for each element in a unit or trying to incorporate a variety of maps into the instruction, as well as

having the time to adequately develop the maps, were a common theme. One wrote that some maps could be used more easily for science concepts than others.

The students of teachers who reported that they used Thinking Maps® regularly and consistently scored higher than those students of the teachers who did not have a positive perception of or who did not use Thinking Maps® regularly in their classes.

Research Question 3

What, if any, is the relationship between the use of Thinking Maps® and teachers' perception and implementation in middle grades?

Based on the results from statistical testing in SPSS and SAS, and perceptions of science teachers who felt favorably towards using Thinking Maps® regularly in their science classes, it can be concluded there is a trend in the perception and consistent usage of Thinking Map® in the middle grades science classes and the increase in achievement score means of the students who use them regularly. Additionally, because an interaction effect cannot be calculated due to the variance in the data to report a relationship, a comparison of the means for each grade level and non-usage or usage of Thinking Maps® showed that in four out of six instances (67%) that students who used Thinking Maps® scored a higher mean than students who did not use Thinking Maps®.

ANALYSIS OF RESEARCH FINDINGS

Data analysis of the Georgia CRCT science test scores was completed with SPSS 24 and SAS. For the 2012-2013 data, non-parametric statistical testing indicated that grade level had an effect on the scores, and that the seventh grade had the greatest variance in scores. Further

testing for non-usage and usage indicated that usage of Thinking Maps® did not have an influence on the CRCT scores to a statistically significant degree. Friedman's non-parametric ANOVA was used to determine the influence of both grade level and amount of usage on the CRCT science scores. The model was significant, revealing that grade level and usage of Thinking Maps® together explained 9.11% of the variance in the CRCT scores. However, because the scores followed a non-normal distribution, and the CRCT scores did not originate from the same distribution, it was difficult to determine if the interaction between grade levels and Thinking Maps® were significant.

For the 2013-2014 data, non-parametric statistical testing indicated that grade level had an effect on the scores to a statistically significant degree. Again, the seventh grade had the greatest variance in scores. Testing for non-usage and usage of Thinking Maps® showed that usage of Thinking Maps® had an influence on the CRCT scores. Friedman's non-parametric ANOVA was used to determine the simultaneous influence of both grade level and amount of usage on the CRCT scores. The model was significant, indicating that grade level and usage together explained 23.2% of the variance in the CRCT scores. Again, because of the non-normal distribution of the data, and because the CRCT scores did not originate from the same distribution, an interaction effect was difficult to interpret.

DISCUSSION

Based on results from non-parametric statistical testing, the 2012-2013 and 2013-2014 data showed that grade level had an influence on CRCT scores in science, and that the combination of grade level and usage explained 9.11% and 23.2% of the variance in the scores, respectively. Additionally, the usage of Thinking Maps® had an effect on the CRCT scores as related to the 2013-2014 data.

In a comparison of these findings with the review of literature, it was revealed that of the thirteen studies conducted on the use of Thinking Maps®, including advance organizers or other graphic organizers, eight of the thirteen, or 62%, focused on elementary students, three of the thirteen, or 23%, focused on college students, and only two of the thirteen, or 15%, focused on middle school students (see Concept Analysis Chart, p. 39). Only one of the two studies reported included quantitative data regarding achievement test scores. Ausubel (1960) used advanced organizers with college students to determine if learning could be facilitated, which was shown by an increase in assessment scores. Ball (1998) used Thinking Maps® to improve reading scores, with 5 of 7 variables showing improvement, and Gallagher (2011) using Thinking Maps® when generating writing about dietary articles. Articles written by the students were better organized and the clarity of the writing improved.

At the elementary level, Hyerle (2000) used Thinking Maps®, showing gains in reading, writing, and math without reporting the data he collected. Chang, et al., (2002) revealed that concept mapping aided fifth graders in knowledge acquisition. Brown (2003) tested to see if fourth graders could develop higher-order comprehension tests for their peers using Thinking Maps®. Hickie (2006) found there was a difference in using Thinking Maps® in reading and language arts with fifth graders, and Gibbs (2009) showed that use of Thinking Maps® influenced reading scores with third and fourth graders. Leary (1999), Russell (2010), and Sunseri (2011) reported no difference in the achievement scores of students who used Thinking Maps® over those who did not use Thinking Maps®.

Of the two studies at the middle grades level, Hester, et al., (1995) reported an “upswing” in achievement test scores and “outstanding” growth in reading and writing, but did not report

any data. DiCecco and Gleason (2002) reported that using graphic organizers helped increase achievement test scores of learning disabled (LD) students over those who did not.

Based on the review of literature, therefore, it is difficult to make a comparison when either the data is missing with which to compare it or the program being tested does not support the dependent variable. Because Hester, et al., did not report the actual data collected, and because DiCecco and Gleason were using graphic organizers and not true Thinking Maps®, the data regarding Thinking Maps® is lacking for the middle grades and for science. This study, then, is important to the literature in that it presents data collected at the middle grades level and for the science content area using Thinking Maps® and not another program.

CONCLUSIONS

This study sought to determine if there was an effect of the usage of the Thinking Maps® program on middle grades' students' science achievement test scores on the 2012-2013 and 2013-2014 administrations of the Georgia CRCTs. The primary question that was raised in the study was if there was an effect in achievement as measured by the state-mandated content area tests for three grade levels. The results from data analysis concluded that grade level had an effect on the achievement scores and that the combination of grade level and usage explained 9.11% and 23.2%, respectively, of the variance in the scores over the two years of the study. However, usage did not have a statistically significant effect during the 2012-2013 study year, but did show a statistically significant effect during the 2013-2014 study year. Studies completed by DiCecco and Gleason (2002) and Hester, et al., (1995) were they only studies at the middle grades level. DiCecco and Gleason's study focused on graphic organizers and not specifically Thinking Maps®, and Hester's study included results but was not supported by a reporting of the data.

The second question examined teachers' perceptions of the Thinking Maps® program, seeking to reveal if a positive perception by the teacher might have a secondary effect on the achievement scores. Eighty-six percent of the respondents said they believed Thinking Maps® help students learn science content, but several did not use them due either to a dislike of the program or because of the challenges inherent in using them, such as using a variety or maps and a lack of time for the students to practically develop them. The students of those teachers who regularly used Thinking Maps® had a higher mean than those who did not.

The final question sought to unify the two previous questions to see if not only the usage of Thinking Maps® affected achievement test scores, but that the science teachers' perceptions regarding Thinking Maps® affected achievement test scores simultaneously. Based on the statistical testing and the positive perceptions of over 80% of the science teachers, it can be concluded that there is a trend in the simultaneous positive perception and consistent usage of Thinking Maps® in the middle grades science classes and the increase in achievement score means of students who use them consistently and with fidelity.

Based on the review of literature and the findings from statistical testing and teacher perceptions, it may be concluded that Thinking Maps® have an effect on the achievement scores of middle grades students in science when used consistently and with fidelity. The number of previous studies at different levels attributes to this conclusion, starting with Ausubel (1960), Ball (1998), and Gallagher (2011) having positive results at the collegiate level. At the elementary level, Chang, et al., (2002) saw results with concept mapping, and Gibbs (2009) and Hickie (2006) saw results with Thinking Maps®. Others, including Brown (2003) and Hyerle (2000) discussed positive results with Thinking Maps®, while Leary (1999), Russell (2010), and Sunseri (2011) reported no effect of Thinking Maps® on achievement. The researcher has

witnessed increased student achievement, not only in the classroom, but on formal and informal assessments when Thinking Maps® and other visual-verbal organizers were used with consistency. The ability to organize and manipulate information appears to be the deciding factor.

RELATIONSHIP TO RESEARCH

In a comparison of these findings with the review of literature, it was revealed that of the thirteen studies completed using Thinking Maps®, including advance organizers or other graphic organizers, eight of the thirteen, or 62%, focused on elementary students, three of the thirteen, or 23%, focused on college students, and only two of the thirteen, or 15%, focused on middle school students (see Concept Analysis Chart, p. 39). Only one of the two studies at the middle school level reported included quantitative data regarding achievement test scores. Ausubel (1960) used advanced organizers with college students to determine if learning could be facilitated, which was shown by an increase in assessment scores. Ball (1998) used Thinking Maps® to improve reading scores, with 5 of 7 variables showing improvement, and Gallagher (2011) using Thinking Maps® when generating writing about dietary articles. Articles written by the students were better organized and the clarity of the writing improved.

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Of the two studies at the middle grades level, Hester, et al., (1995) reported an "upswing" in achievement test scores and "outstanding" growth in reading and writing, but did not report any data. DiCecco and Gleason (2002) reported that using graphic organizers helped increase achievement test scores of learning disabled (LD) students over those who did not.

Based on the review of literature, therefore, it is difficult to make a comparison when either the data is missing with which to compare it or the dependent variable is not supported by the program being tested. Because Hester, et al., did not report the actual data collected, and because DiCecco and Gleason were using graphic organizers and not true Thinking Maps®, the data regarding Thinking Maps® is lacking for the middle grades and for science. This study, then, is important to the literature in that it presents data collected at the middle grades level and for the science content area using Thinking Maps® and not another program.

IMPLICATIONS FOR PRACTICE

Educators are constantly on the lookout for the next program to help their students learn their content area curriculum. They rely on researchers to have tested the program for success based on the claims made by the developers. Since there is a lack of evidentiary support for student achievement at the middle grades level, there must be research and testing to determine if the program can live up to the claims, that is, can achievement scores at the middle school level be increased by using this program? If the program does not live up to its claim, then the money spent on it is wasted. Therefore, it is necessary to complete statistical testing so that the funds are used to the benefit of the students.

Achieving in science at the middle school level, given the challenges facing middle schoolers, is a short-term implication. The long-term implication is that the students learn how to organize and utilize information for better processing and retention, which is a life skill. This achievement links the short-term to the long-term. If the usage of Thinking Maps® helps students, at any level, learn to organize and use information for a variety of purposes, then it is worth the price paid for it. However, if it does not help students learn, it should not be continued, and other programs should be explored for their ability to help students learn science content, or any other content. Using a program that does not work is analogous to pedaling furiously on a bicycle bolted to the floor. You can pedal all you want, but you will not get anywhere. A student using a program that makes no discernible difference in his ability to learn instructional content or excel on assessments is being deprived of his ability to learn, grow, and succeed.

RECOMMENDATIONS

Based on the findings of this research study, the first recommendation would be to continue studying the Thinking Maps® program, not only at the middle grades level, but at the other levels as well. Knowing if the program does what it is purported to do will better ensure that students receive the most benefit. This program, while having some data on which to fall back, needs the benefit of more study. Along that line, it is also recommended to replicate this study in districts with different demographics from the selected school within five years.

Another recommendation to the developers and trainers of Thinking Maps® would be to provide more examples and templates of the maps to prospective users of the program for content areas. A complaint among the science teachers on the teacher survey was that teachers had a difficult time planning or finding a variety of maps for their instructional objectives in their

content area. Providing more examples and templates for those content areas would help to foster usage among the educators, helping teachers see Thinking Maps® in a more positive light, and ultimately helping the students learn those instructional objectives.

A final recommendation would be to those researchers who completed formal and informal testing or studies of the use of Thinking Maps® and yet did not report those findings. It does the program under scrutiny no good service if you report the findings and then do not back it up with the quantitative (or qualitative) data results.

DISSEMINATION

Sharing information is crucial to educators. When teachers find something that works, or does not work, it is important for them to share that information with their colleagues. Prior to getting approval for the study, the researcher was interviewed by the assistant superintendent for instruction and a plan was formulated to present the results of the study to her and to the faculty of the four middle schools at a professional development seminar. This also includes the faculty at the selected school. Additionally, an article for the *Middle School Journal*, a refereed journal published by the Association of Middle Level Education (AMLE) will be prepared and submitted for publication.

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APPENDIX A

Survey Questions for Teachers on Perceptions and Use of Thinking Maps®

Thinking Maps® Teacher Perception Survey

Our goal is to find out your beliefs, views, or perceptions about Thinking Maps®.

Please do not write your name on this survey. Please answer each question honestly. Your answers will be confidential.

Place a check or X beside your answer choice for each category.					
Age	21-30	31-40	41-50	51-60	61+

Gender ______Female ______Male Grade ___6 ___7 ___8

Years Teaching ___0-5 ___6-10 ___11-15 ___16-20 ___21-25 ___26-30 ___31+

1. In which science subject area do you primarily use Thinking Maps®? ___Earth & Space ___Life ___Physical

Choose *yes* or *no* by placing a check or an X beside your answer choice for each question.

2. Did you receive training in Thinking Maps® in 2008-2009? ______yes ______no

3. If no, did you receive formal training in Thinking Maps®? ______yes ______no

4. Do you believe Thinking Maps® help students learn science content? ______yes ______no

Please order from 1-3 as you choose which Thinking Maps® best answers each question.

	Thinking Maps®							
Question	Brace	Bridge	Bubble	Circle	Double Bubble	Flow	Multi-Flow	Tree
5. In your opinion, which 3 Thinking Maps® do you believe are most effective?								
6. In your opinion, which 3 Thinking Maps® do you believe are least effective?								
7. Which 3 Thinking Maps® do you utilize the most? 1 = used most								

Circle the number that best matches the description of your answer to the question.

8. How often do you use Thinking Maps®?

1	2	3	4	5
Every day	3x a week	2x a week	Once a week	Never

9. How often do you use Thinking Maps® with a class?

1	2	3	4	5
6-7x a day	4-5x a day	2-3x a day	Once a day	Never

Please answer each question and explain clearly.

10. Describe how you typically use Thinking Maps® in your classes and please give an example.

11. As a professional educator, do you believe Thinking Maps® achieve the outcome for which they were designed, to help students organize, manipulate, and learn information? Please explain and give examples that support your response.

12. What has been the most challenging aspect of using Thinking Maps® in your daily practice?

Thank you for completing our survey!